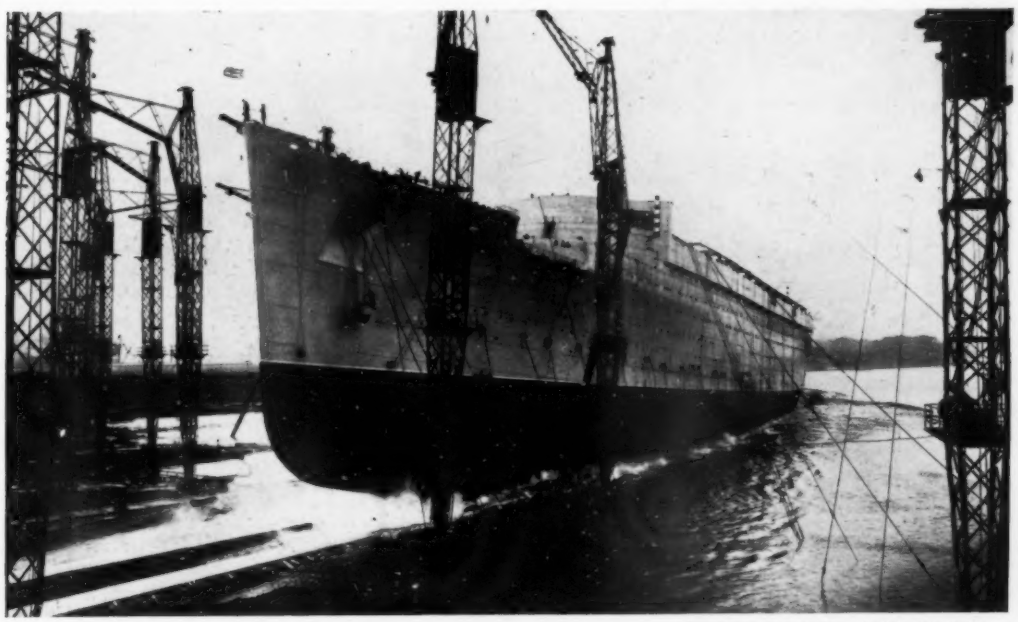
METALLURGIA

THE BRITISH JOURNAL OF METALS.

OCTOBER, 1934. VOL. X., No. 60.

New Cunard-White Star Liner "Queen Mary"

The history of transatlantic passenger traffic makes fascinating reading, and the part played by British ships and seamen stirs national pride. Not less fascinating, however, is the work involved in building one of these mammoth vessels, particularly the new Cunard White Star liner recently launched, which is confidently expected to regain for Britain the Blue Riband of the Atlantic. Brief reference is made to this vessel in this article.



From photograph by Stewart Bale, Liverpool.

The launch of the Cunar-dWhite Star liner, Queen Mary.

THE recent launch of the *Queen Mary* by Her Majesty the Queen has once again focussed world-wide interest in a British enterprise which embodies the very latest ideas in speed, safety, and comfort. It has opened another chapter in the history of the transatlantic passenger traffic and given a further stimulus to the development of marine engineering and of metals and alloys to withstand the high stresses progress of this character implies. The keen rivalry and competition which has been associated with this traffic for so many years has served as a continual stimulus to development and progress, and the "Blue Riband of the Atlantic" is a synonym which has come to be recognised as a household word.

Many nations covet the honour and prestige of building the fastest Atlantic liner, but the desire is not limited to nations, each shipbuilding centre aspires to the privilege of building the vessel to achieve distinction in this respect, and competition is very keen. It is probably, however, that the Clyde has provided the greater number of vessels of this type, and the experience of her shipbuilders has contributed in no small measure to the order for this vessel being placed with John Brown and Co., Ltd. But it will be appreciated that the claims of other important shipbuilding areas like the Tyne, the Mersey, Belfast, and Barrow were not lightly passed over, for each of these districts has contributed their quota to maintaining the prestige of the British mercantile marine.

For many years the supremacy of British vessels in the Atlantic service was recognised, particularly the early reciprocating engined liners, as they developed from compound working to the triple expansion engines. Later, however, the Hamburg-Amerika and Norddeutscher Lloyd express liners, fitted with six-cylinder quadruple expansion engines, carried all speed honours before them. These vessels, with a speed of just over 23 knots, remained for many years the fastest liners on passenger service. The development, however, of the steam turbine by the late Sir Charles Parsons presented an opportunity for a further advance, and the building of the *Lusitania* and *Mauretania* enabled British prestige in the North Atlantic to be restored. Although launched as far back as September, 1906, the *Mauretania* held speed honours for more than a decade. It was thought that finality had been reached, but the development of high-pressure steam machinery indicated the trend of further progress, and ultimately the entry into service of the Norddeutscher Lloyd liners *Bremen* and *Europa*, followed shortly afterwards by the Italia Company's *Rex* and *Conte di Savoia*, effected considerable reduction in the time of crossing the Atlantic.

Protracted Investigations Regarding Developments.

The policy pursued in all this advance has been to take advantage of the latest developments in materials and machinery for the purpose of building what was hoped

to prove the fastest merchant on the high seas. In view of the many factors to be considered, the decision to build further vessels would not be made without a very careful consideration of the known facts regarding developments. Some indication of this is given in the statement of Sir Percy Bates, the chairman of Cunard White Star, Ltd., in which he said that the size and speed of the new liner were no greater than was considered essential by the owners of the ship to provide—along with a similar ship—the contemplated weekly service between Southampton and New York. The dimensions of the ship were the result of protracted consideration of the requirements of weight and space to be allowed for the various items of hull structure, accommodation, and hotel services, propelling machinery, fuel, water, stores, etc., in association with such a power as would enable the owners to ensure the maintenance of a regular service with a definitely scheduled time table between the terminal ports.

The result of these investigations indicated at an early stage that the magnitude of the hull structure would be such that questions of its scantlings and strength lay well outside the former limits of experience. In the light of its previous knowledge of large ship design and construction,

The stern frame casting, by Darlington Forge Co., Ltd., weighing 190 *tons, in the machine shop.*

John Brown and Co., Ltd., which firm have built the *Aquitania*, the *Lusitania*, the *Empress of Britain*, and H.M.S. *Hood*, were able to collaborate with the owners' naval architect and superintendent engineer in a thorough investigation of the structural design, having continuously in view the provision of ample strength to meet the worst conditions of North Atlantic service, any suggestion of reducing weight at the expense of an adequately strong structure being quite inadmissible. The scantlings and structural arrangements developed have subsequently received the complete approval of Lloyd's Register, under whose special survey the ship is being built. She will be given their highest classification, 100 A1, with a freeboard corresponding to the maximum draught permitted by the Board of Trade sub-division regulations. The vessel will meet the full requirements of the Board of Trade, including the latest legislation implementing the International Convention for the Safety of Life at Sea, which governs sub-division, life-saving appliances, etc.

Experiments to Determine Hull Form.

A major factor in the preliminary design investigations was the question of the most suitable hull form to be adopted, both from considerations of speed and the associated minimum power and of sea-kindliness and the resulting comfort of passengers. On this point the builders had carried out a most extensive programme of model experiments in the experimental tank at Clydebank before final decisions were made. Over 7,000 experiments on numerous models were conducted, and all the practicable variations in form which offered any improvement in performance were fully tested. In addition, complete investigations were made in a study of the most suitable propellers for the selected form. Other research investigations included steering experiments, rolling and bilge keel experiments.

Propelling Machinery.

In view of the size of vessel contemplated to run a weekly service economically, the most careful consideration was necessary to determine the most suitable type and design of the main propelling machinery. In order to obtain the best possible advice the directors of the Cunard Company appointed a committee to study the whole problem. This committee, under the chairmanship of the late Sir Aubrey Brocklebank, Bart., comprised the late Sir Charles Parsons, the late Mr. Andrew Laing, Eng. Vice-Admiral R. W. Shelton, Mr. G. L. Paterson, Mr. T. McPherson, Commander Sir Charles Worthington Craven, Mr. J. Callender, the late Mr. Andrew Hamilton, Sir Thomas Bell (managing director of John Brown and Co., Ltd.), and Mr. J. Austin (the superintendent engineer of the Cunard Company). This Committee decided to recommend the adoption of high-pressure, high-temperature steam raised in oil-fired watertube boilers, with single reduction geared turbine propelling machinery. This recommendation was duly adopted, and on December 1, 1930, the order was officially placed with John Brown and Co., Ltd. The keel was subsequently laid, and the work of construction begun. On account of financial difficulties, work on the ship and her engines was suspended on December 10, 1931, and was only resumed again on April 3, 1934. It is expected that the new liner will be completed early in 1936.

Official Dimensions.

The official dimensions of this vessel indicate an overall length of 1,018 ft.; beam, 118 ft.; depth from keel to highest point of the superstructure, about 135 ft.; and depth from keel to truck, 234 ft. Her main propelling machinery will consist of quadruple-screw Parsons type single-reduction geared turbines, with an approximate total power output of 200,000 s.h.p. Steam at a pressure of 400 lb. per sq. in. and a temperature of 700° F. will be supplied from oil-fired Jarrow type boiler, of which there are 24 to be installed. The total approximate weight of hull and machinery will be about 55,000 tons, while the launching weight of the hull was approximately 40,000 tons. The vessel is designed to accommodate 4,000 persons, comprising passengers, officers, and crew.

Design and Structure of Hull.

The ship has a sloping stem and a cruiser stern. She will carry the usual fore and aft rig, and three large funnels of suitable rake and height, to ensure that the funnel gases will clear the promenades on the superstructure decks. In all there are 12 decks, comprising the sun deck, the upper promenade deck, the promenade deck, and "A" to "J" decks, including the partial lower decks, which are discontinued in the way of the machinery spaces. The principal sub-division is effected by 18 transverse watertight bulkheads, while the double bottom, covering the whole length of the hull, contains 70 main compartments. If account is taken of the additional sub-division afforded by the inner skin the engine-rooms, and the side oil bunkers in the boiler-rooms, there is a total number of 160 watertight compartments below the bulkhead deck, and it will

be seen that the question of strength and safety has been met in compliance with the latest and most recent scientific investigations into hull structures. The question of materials was also carefully investigated, and many different types of steel decided upon to satisfy requirements in different parts of the structure.

In considering the design of the upper works, the longitudinal strength of the ship was very carefully taken into account. In order to ensure that stresses of too great a magnitude shall not be incurred in the upper members, the superstructure has been divided into convenient sections by three expansion joints extending from the promenade deck upwards. The necessarily large stresses which have to be withstood by the strength decks and sheer strakes of the shell plating, which comprise the upper flange of the main hull girder, called for the use of double plating over a considerable portion of this region, but excessive thicknesses and weight have been avoided wherever necessary by the incorporation in this part of the structure of a large amount of high-elastic limit steel. The side framing is a combination of main frames of channel section, in combination with relatively close-spaced web frames, each about three frame spaces apart, throughout the whole length. These webs are generally carried in one transverse plane right up to the strength deck, and in association with partial bulkheads in the side bunkers and 'tween decks, and webs in the superstructure houses, form a very ample provision against any transverse racking forces which may be experienced. The thickness of the plating of the shell varies from 1 in. to 1·2 in., and the plates used range from 8 ft. to 30 ft. in length, with weights from one-tenth of a ton up to 3 tons.

Generally the beams are of channel section, with the addition of angle reverses where the requirements of special conditions call for extra strength and stiffness. They are usually supported by four rows of close-spaced pillars or suitably stiffened pillaring bulkheads. The massive nature of the structural work will be appreciated when it is realised that about 10,000,000 rivets have been used, having a weight of about 500 tons, supplied by the North-West Rivet, Bolt and Nut Factory, Ltd ; they were made from Siemens Martin steel, to comply with Lloyd's requirements.

Main Hull Castings.

Another impression of the size of this vessel is conveyed by the main hull castings, comprising the four shaft brackets, the stern frame, rudder post, and stock. The total weight of this group of castings, supplied by the Darlington Forge Co., Ltd., exceeded 500 tons, and required approximately 1,000 tons of metal to cast. Although the characteristics of the steel used in the manufacture of these castings corresponds to that for similar castings, their size presented problems that demanded considerable skill in their solution. It will be appreciated that the high temperature of the fluid metal, the widely varying thicknesses of metal in the castings, and the unwieldy size of the various parts increase the difficulties. Some indication of the work involved is given by the fact that the mould for the main part of the stern frame, working three shifts per day, occupied five days to close and make ready for casting. The majority of the cores were made in the mould, and, after being dried, assembling had to proceed without undue delay, but with a view to security. It is noteworthy that the part referred to was cast between 3 and 4 o'clock in the morning, and required 110 tons of steel.

An important aspect in the production of these castings is that cost is relatively of secondary importance, nothing is left to chance, and every known precaution taken to ensure soundness. Of the many problems presented not the least results from the high contraction of the metal when cooling to a normal temperature ; this will be appreciated when it is realised that $\frac{1}{8}$ in. per foot was allowed for contraction, much of which takes place immediately on solidification when the steel is weak in comparison with the mould.

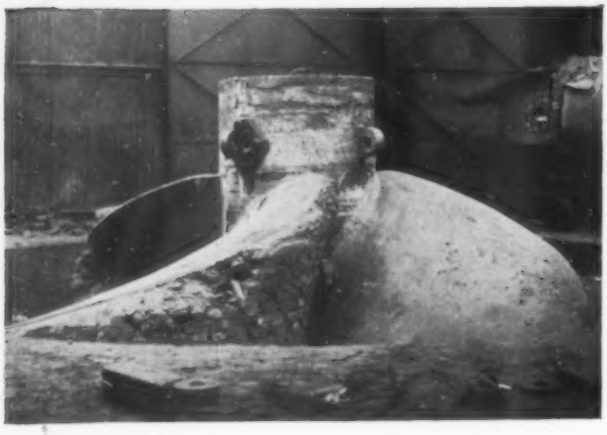
Casting the largest portion of the stern frame between 3 and 4 a.m., at the foundry of Darlington Forge Co., Ltd.

Some of these castings remained in their moulds for about a fortnight before they were considered cool enough to lift for rough cleaning preparatory to annealing, which presented its own problems. The awkward shapes and the wide variance in metal thickness increase the difficulties of annealing, particularly as it is necessary to attempt to rectify any alteration in shape produced by contraction.

Main Propelling Units.

Each of the four main propelling units, which will be capable of being operated independently, will consist of a high-pressure, first intermediate-pressure, second intermediate pressure, and low-pressure turbine and a condenser. The revolutions of the turbine rotor will be reduced to the propeller speed by means of single-reduction double-helical gearing. Great care has been taken to ensure accuracy in the hobbing of the gear-wheel and pinion teeth in order to reduce noise and vibration to a minimum. Each propelling unit will be available for manœuvring purposes, astern turbines being incorporated in each of the second intermediate-pressure and low-pressure casings. The main condensers, which are double flow and of quite exceptional size, are fitted throughout with cupro-nickel condenser tubes manufactured by Messrs. Imperial Chemical Industries, Birmingham. The feed-pumping and heating system for the main boilers has been designed by the builders in collaboration with Messrs. G. and J. Weir, Ltd.,

The inner shaft brackets, made by the Darlington Forge Co., Ltd., weighing 120 tons.



Propeller in mould with covers removed in the foundry of the Manganese Bronze and Brass Co., Ltd.

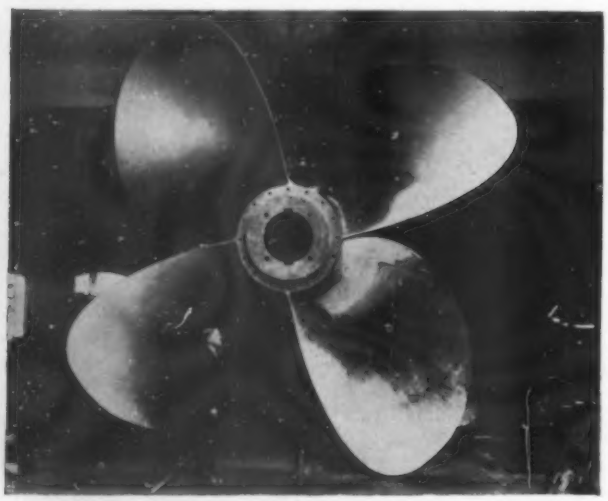
Cathcart, the latter firm providing the necessary feed pumps, feed heaters, etc. The arrangement will incorporate three-stage feed heating, the heating steam being bled from the high-pressure, first intermediate pressure, and second intermediate pressure turbines, and augmented by the exhaust from the turbo-feed pumps.

Manganese Brass Propellers.

Many factors contribute to the all-important question of speed, and not the least of these is to be found in the design and the materials used for the propellers. Eight large bronze propellers were ordered for the *Queen Mary*, and of these four will be working and four spare, the order being divided between the Manganese Bronze and Brass Co., of Millwall, and Messrs. J. Stone and Co., of Deptford. Those supplied by the latter company are made of Turbiston bronze, and for each casting 53 tons of this alloy was used. The propellers are four-bladed, are nearly 20 ft. in diameter, and the finished weight of each is 35 tons. These propellers are the largest in the world, and exceed the next heaviest by over 10 tons.

From sails to paddles, and paddles to screws were revolutionary steps, and until 1879 the propellers or blades were cast in iron, steel, or gunmetal. That year saw a discovery of far-reaching importance—the invention of manganese bronze by the late Mr. P. R. Parsons. As an engineer, he visualised the immense possibilities of the new alloy, and was not slow to realise that it presented many decided advantages over the materials then in use for propellers, on account of its resistance to corrosion, its comparatively high strength and ease of casting. His original alloys were of the true bronze class—*i.e.*, they were of copper-tin strengthened by the addition of suitable proportion of ferro-manganese which was completely alloyed. After numerous experiments, it was discovered that remarkable properties were developed when similar additions were made to brasses—*i.e.*, the alloys of copper and zinc, and whilst the bronzes were retained for bearing metals, they were superseded by the manganese brasses for propellers and for hydraulic pumps and valves. The name of the company founded 52 years ago to manufacture these alloys remains unchanged—the Manganese Bronze and Brass Co., Ltd.,—and it may be claimed that the original Parsons manganese bronze was the foundation from which arose the present series of alloys known as high-tensile bronzes and brasses. Exactly 50 years ago this company erected the first foundry in the world for casting manganese bronze propellers, and this was on the banks of the Thames. Since then there has been maintained a steady output of blades and propellers, and large sums of money have been expended on research devoted to improving the design, the finish, and the quality of the product.

Finished Propeller as supplied by Messrs. J. Stone and Co., Ltd.



In the early days the working conditions—that is, the speed and the power transmitted—were not so exacting as to-day, and a tensile strength of about 30 tons per sq. in., with good ductility and shock-resisting properties, coupled with immunity from sea water corrosion, were readily obtained, whilst the added advantages of reduced weight, true pitch and the high finish all helped to give better efficiencies, increased speed, and lower fuel consumption than had been possible with ferrous materials.

From the *Engineer* of May, 1889, we learn that at that date "Seventeen ships of the White Star Line have propellers of manganese bronze, as well as ten belonging to the Cunard Company." These included various record breakers of the two companies responsible for the *Queen Mary*, and outstanding ships of other lines, which in turn held the honour of the fastest crossing. An excellent idea of the severity of the service which has to be rendered by such propellers is given by the fact that one of the propellers made by the Manganese Bronze and Brass Co., Ltd., was in continuous use on the famous *Mauretania* for 15 years, and even then was only removed on account of accidental damage.

With the advent of the steam turbine as the propulsive power, the propellers were called upon to face entirely new service conditions of speed and power. The original brasses consisted of the well-known duplex alpha-beta structure, and whilst these had proved completely satisfactory for the conditions then existing, and the life of a propeller was equal to the life of the ship, the new conditions brought the problem of erosion very much to the fore.

As the result of an investigation on the "Erosion of High-speed Propellers," under the direction of the late Sir Charles Parsons, which has come to be regarded as classical, it was shown that water hammer or cavitation due to the collapse of vacuum cavities caused by the movement of the propeller was one of the prime causes of erosion. In the light of this knowledge prolonged research was undertaken, which led finally to the production of an alloy known as Turbadium, characterised by an all beta structure, which was capable of resisting this erosion. For a long time the view had been maintained that an alloy consisting only of the beta structure would be too hard and brittle to have any commercial value, but the required degree of toughness and ductility was attained by suitable additions of nickel and a careful adjustment and control of the other added metals. The alloy has an ultimate strength of about 40 tons per sq. in., with an elongation of about 20%. Continuous research is in progress into all the problems connected with this special class of work. The Turbadium for the propellers of the *Queen Mary*, supplied by Manganese Bronze and Brass Co., was first made in crucible furnaces,

to ensure perfect alloying of the high melting point constituent metals, and then cast into ingots. It has been found that this first melting is essential to effect the combination at high temperature of the more refractory metals, and the ingoting allows for the elimination of gases absorbed during this process.

The second melting, in bulk, for the casting process, was carried out in large reverberatory furnaces with medium-pressure forced draught. The melting conditions were carefully controlled throughout, overheating being scrupulously avoided, and only the necessary degree of superheat was reached to provide perfect mixing and the maximum fluidity with the minimum production of dross when the metal enters the mould.

Safety Measures.

Safety of lives at sea is a big factor which has to be considered when designing a passenger-carrying vessel, and by the recommendation of the International Convention for Safety of Lives at Sea and the Regulations of the Board of Trade, all passenger-carrying vessels must be fitted with controllable watertight doors fitted in the bulkheads. It is interesting to note that a British system was the pioneer system for the central control of the bulkhead doors, and was designed and patented by Messrs. J. Stone and Co., Ltd., of Deptford, London, S.E., over 30 years ago. This system is still claimed to be the premier and most used system in the world, and many cases can be instanced where the prompt sub-divisioning of a vessel by this system has saved many hundreds of lives and has enabled the damaged vessel to be towed into port, thus saving the vessel itself and a valuable cargo.

This is the system which is fitted on the *Queen Mary*, and is known as Stone's system for hydraulically controlling bulkhead doors. In the most vulnerable parts of the ship, watertight doors are fitted to enable free passage from one watertight compartment to another. The successful operation of these doors must be ensured, otherwise, in an emergency, the very existence of the ship would be placed in jeopardy should the doors fail to close. There are 38 watertight doors, four sliding vertically and 34 sliding horizontally, and they range in size up to 6 ft. 8 in. high and 5 ft. wide, sufficiently large to enable a motor-car to pass through. The doors in some positions are capable of withstanding a load of 27 tons—*i.e.*, the door would bear the weight of 430 persons of average weight and still remain watertight. There are two pumps, either capable of delivering sufficient fluid, at a pressure of 700 lb. per sq. in. for closing all watertight doors in less than 1 min. from the commander's orders to "Close watertight doors," even though there is a distance of 750 ft. from the point of operation to the farthest door. A previous warning of approximately 7 secs. being given by an electric bell at each door before door commences to close. When doors have been closed from the bridge, each door can be opened from either side of the door locally, and will automatically reclose, so that there is no likelihood of any persons being trapped in any one watertight compartment, and at the same time ensuring absolute safety to the ship. Irrespective of the pressure control, each door can be closed by hand. The pressure control gives an operating load in excess of 6 tons in the hydraulic cylinders, being able to crush through obstructions. For the information of the commander on the navigating bridge, an indicator is installed showing the position and number of each door in the ship. The closed doors are shown in the illumination of the individual numbers engraved on coloured discs.

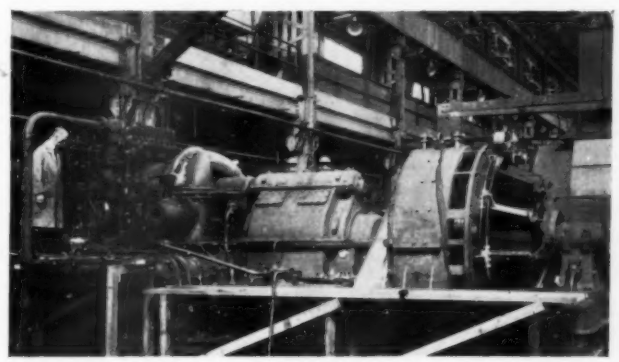
The system is divided into two sections. One section consisting of all the doors in the hold; the other section those on the passenger accommodation decks; each section can be operated either independently or simultaneously. Two miles of solid drawn copper piping carries the necessary fluid to each door and from the commander's bridge.

Special precautions will be taken against risks from fire. The cargo holds in particular are to be installed with large batteries of "Lux" cylinders supplied by the Walter Kidde Co., Ltd. These are arranged "fore and aft," and connected by means of three-way valves placed at control positions at the fire stations, so that carbon dioxide can be rapidly injected into any cargo space. Special provision has been made for dealing very quickly with fire in the large motor-car space. Combined with the "Lux" CO_2 system is the latest type of "Rich" smoke-detecting apparatus, indicating on both the bridge and at the fire stations should the slightest trace of smoke appear in any hold. Upwards of 23 holds and stores are automatically protected by the Lux-Rich system.

Electrical Equipment.

Of the numerous auxiliary equipment units, reference will be made at a more appropriate time, but the most important auxiliary equipment—the generating machinery for lighting and the many electrically-driven units—may be briefly mentioned. The whole of the electric generating plant is manufactured by British Thomson Houston Co. This plant includes seven turbo-generators, each rated at 1,300 kw. (normal) 225 volts, with an overload capacity of 25% for 2 hours, and 50% for 5 mins. The combined normal capacity is therefore 9,100 kw., which is sufficient for the needs of an average town of about 100,000 inhabitants.

Each set comprises a 10-stage turbine (with condenser), driving a direct current generator through single reduction



One of the turbo-generators supplied by British Thomson-Houston Co. Ltd.

gearing, the speed of the turbine being 5,000 r.p.m., and the speed of the generator 600 r.p.m. The sets are of the combined turbine and condenser type, in which the condenser is integral with the turbine, thus enabling the whole unit to be on the one floor level. Four of the sets are designated "Main Machinery Sets," and three "Hotel Service Sets." The former will supply power to the numerous motor-driven auxiliaries, and are designed for steam at the stop valve at 370 lb. per sq. in. gauge, 680° F. total temperatures. The hotel service sets will supply the electrical energy for lighting, heating, cooking, ventilation, lifts, pumps for sanitary service, swimming baths, etc. As they will be required for service in port as well as at sea, steam will be supplied from auxiliary boilers—the steam at the turbine stop valves having a pressure of 230 lb. per sq. in. gauge, 650° F. total temperature. There will be installed also two B.th. 75 kw. generators driven by Parsons oil engines for emergency duty.

Steering Gear.

The complete installation of electro-hydraulic steering gear is supplied by Brown Brothers and Co., Ltd. The gear has been specially designed to meet the requirements of this ship, and is three times as powerful as anything this company has built previously. It consists of a four-ram type gear with five working combinations of cylinders, and

the pressure fluid to the cylinders is supplied by three electrically-driven V.S.G. Mark III. variable delivery pumps. The steering gear is arranged for duplicated telemotor control from the bridge, the telemotors actuating an electro-hydraulic Servo gear coupled up to the controls of the main steering gear pumps. The main pump controls can also be operated by Gyro Pilot, providing automatic steering and as a further standby provision is made for mechanical control. The whole equipment is designed to ensure continuous operation, as practically every part is duplicated, and the steering gear will function despite temporary failure of any one part.

This new vessel will probably become the eighth wonder of the world, and it will be a proud day for Clydebank and for Britain when she goes out on her Board of Trade trials, for she will undoubtedly be a queen in deed as well as in name.

Scientists Discover New Resources in the U.S.S.R.

The first Moscow session of the council for the study of the productive forces of the Soviet Union of the Academy of Sciences was held on September 3. In opening the session, Academician Gubkin said that the removal of the Academy to Moscow signalised a new stage of joint work of the Academy, the State Planning Commission, the Commissariats and the economic institutions. V. N. Vasilyev, scientific secretary of the council, in a report on its work, pointed out that Soviet scientists and explorers are discovering enormous resources, which further the work of socialist construction. Thus, the desert tundras of the Kola Peninsula have been transformed into an advanced polar industrial centre, rich sources of oil have been discovered on the plains of the Caspian, mines and metallurgical plants have sprung up in the mountain valleys of Transcaucasia. The Academy of Sciences is playing a big part in all this work. Its twelve comprehensive expeditions and eighteen branch expeditions are studying the natural resources in the most distant corners of the Soviet Union. Five hundred scientific workers are taking part in these expeditions.

Academician Fersman reported on the work of the comprehensive expedition for the study of the Kola Peninsula, which it is exploring for deposits of ores and rare elements, and is carefully bringing to light deposits of pyrites, iron and non-ferrous ores. It is also engaged in studies of the soil for the organisation of agriculture on the peninsula.

Academician Levinson-Lessing and Professor Kremmer spoke of the scientific work on the Kamchatka Peninsula, of which a considerable territory still offers many problems. The exploitation of the natural resources of Kamchatka are of exceptional importance for the economic development of the Far East. Deposits have been discovered of coal, oil, iron, non-ferrous and rare metals, and the peninsula contains enormous fur resources and fish.

Non-ferrous Metal Production in Canada.

The article on the above subject, which appeared in our recent August issue, has been favourably commented upon, and we take this opportunity of expressing our indebtedness to Mr. G. G. Ommanney, of the Canadian Pacific Railway Development Branch, who, through the courtesy of Mr. L. L. Bolton, Assistant Deputy Commissioner of Mines, supplied much valuable information. The Canadian Pacific Railway Development Branch at Montreal is well organised to give authoritative and expert information on many matters of vital interest to the metal industries using raw material of Canadian origin, and we are confident Mr. Ommanney would be glad to be of service to our readers in this respect.

Forthcoming Meetings

INSTITUTE OF METALS.

Birmingham Section.

Oct. 25.—"The Production of Brass Ingots." Open discussion.

London Section.

Nov. 8.—"Recent Trends and Future Developments in Metallurgical Research," by M. Moore, C.B.E., D.Sc., Ph.D.

North-East Coast Section.

Nov. 13.—Combined lecture and visit to Armstrong-Saurer Motor Works. Lecture by Mr. Nicholson.

Scottish Section.

Nov. 12.—"The Influence of Manufacture of Wrought and Cast Aluminium Alloys on Design," by W. C. Deveraux.

Sheffield Section.

Nov. 9.—"The Flow of Metals in the Extrusion Press," by C. E. Pearson, M.Met.

Swansea Section.

Nov. 13.—"Copper in Architecture: Some Chemical and other Aspects," by W. H. J. Vernon, D.Sc., Ph.D.

THE ROYAL AERONAUTICAL SOCIETY.

Oct. 25.—"The Compressed-Air Tunnel," by E. F. Relf, F.R.Ae.S.

Nov. 8.—"Speeds of Commercial Aircraft," by M. Louis Breguet.

THE INSTITUTION OF MECHANICAL ENGINEERS.

Oct. 26.—Thomas Hawksley Lecture by Professor Sir Frederick W. Keeble, C.B.E., D.Sc., F.R.S. Subject: "The Green Plant as Agricultural Engineer."

Nov. 2.—Presidential Address by Charles Day, M.Sc.Tech.

Nov. 9.—"The Loeffler System of Steam Production: Its Place in the Sphere of Power Generation," by S. McEwen.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Nov. 2.—The Third Andrew Laing Lecture, by Sir Arthur W. Johns, K.C.B. Subject: "Recent Progress in Naval Architecture."

MANCHESTER METALLURGICAL SOCIETY.

Nov. 7.—"Acceptance Tests for Materials," open discussion, led by L. W. Schuster, M.A., M.I.Mech.E., M.I.E.E.

INSTITUTE OF BRITISH FOUNDRYMEN.

Scottish Branch.

Oct. 27.—"Some Thoughts on Indian Foundry Production," by W. T. Bruce.

Nov. 10.—"Defects in Iron Castings: Their Cause and Cure," by T. Tyrie.

Sheffield Branch.

Nov. 16.—"Suggested Method of Establishing Melting Costs," by a Member of the Costing Sub-Committee.

Birmingham Branch.

Nov. 2.—"Some Possibilities in Foundry Sand Practice," by J. J. Sheehan, A.R.C.Sc.I., A.I.C.

East Midlands Branch.

Oct. 27.—"Cupola Practice," by L. W. Bolton, A.M.I.Mech.E., at Leicester.

Nov. 17.—"Steel Castings," by C. H. Kain, at Derby.

Lancashire Branch.

Nov. 3.—Joint Meeting with the West Riding of Yorkshire Branch.

i.—Visit to the Lancashire Foundry Coke Company's Plant, Altham, Accrington.

ii.—"Description of the Processes at the Altham Coke Plant," by Mr. Hollingsworth.

Burnley Section.

Nov. 13.—"A Day in the Foundry," by F. Harris.

London Branch.

Nov. 14.—"Suggested Method of Establishing Melting Costs in a Grey Iron Foundry" (*Results of Investigations by Costing Sub-Committee*), by V. Delport.

Middlesborough Branch.

Oct. 26.—"Some Recent Developments in Foundry Melting Practice," by H. Cowan, B.Sc.

Nov. 16.—"A Few Notes on Continental Steel Foundry Practice and Castings," by John G. Wrightson.

Newcastle-on-Tyne Branch.

Oct. 27.—"Grey Iron Castings for Laundry Machinery," by J. Longden.

Wales and Monmouth Branch.

Oct. 27.—"Oven Drying of Cores and Moulds," by E. G. Fiegehen, at Cardiff.

Nov. 17.—"The Engineering Properties of Cast Iron," by A. B. Everest, Ph.D., B.Sc., at Newport.

West Riding of Yorkshire Branch.

Nov. 3.—Joint Meeting with Lancashire Branch.

METALLURGIA

THE BRITISH JOURNAL OF METALS.

The Melbourne Air Race.

A Test for Men and Materials.

THERE are a considerable number of people who see no useful purpose in many of the long-distance flights that have been undertaken; they consider the experience gained is not commensurate with the risks inseparable from such flights. So much progress has been made, however, in the design of aircraft, and metallurgical developments have assisted the aeronautical engineer to such an extent, that this opinion is gradually waning. Long distances are now being covered with a remarkable degree of safety, and this great England-to-Melbourne contest may well mark an epoch in aviation and in Empire communications. Progress during the past ten years has been remarkable, and regular services have become organised over gradually increasing distances, and a flying contest of this character is important in view of the early inauguration of the regular England-Australia air service, as well as providing a demonstration of the high-speed mails and passenger aeroplane.

It is doubtful whether a more severe test of the design and materials used in the construction of the competing aeroplanes and the skill and resourcefulness of the pilots could be arranged as in a race of this kind. For some years feverish progress has been made in the development of materials which could be used to withstand the severe stresses encountered by speed planes, and yet possess the minimum weight consistent with safety, but keen rivalry exists in all the developments that contribute to the manufacture of the contesting planes, and the result will have a far reaching influence, not only on the development of commercial flying, but in all the branches of industry that participate in the construction of aeroplanes and their power units. During the last 12 months or so engineers and designers in four continents are making full use of these developments, and have been working on the construction of machines with a view to bringing Australia within three or four days' journey of England.

When this race was first contemplated it was thought by even the more optimistic that not more than about a dozen would enter for such a hazardous flight for the remote chance of winning the £10,000 first prize, particularly as the cost to each competitor would be very considerable. Instead, however, some sixty-four entrance fees were sent to the Royal Aero Club; a very clear indication of the importance with which the event is regarded. Arranged in connection with the Victoria centenary celebrations, which will be attended by the Duke of Gloucester, the event has assumed world-wide significance, and will undoubtedly have an immediate and profound influence on commercial flying.

An interesting feature of this race is the fact that safeguards have been made to preserve it for practical machines, with a view to progress in commercial flying. Considerations for speed machines specially designed for the race are governed by rules laid down by a committee in control, the object of which, apparently, is to foster the development of fast utility machines, rather than freakish machines, which, though they may be in the nature of record breakers, are dangerous and often useless as a basis for commercial enterprise. It is stipulated that the machines must comply with the standard of flight and performance laid down by the F.A.I. An important requirement is that machines, fully laden with fuel and crew, must be able to climb to a height of 66 ft. at a distance of 660 yds. from the beginning of the take-off.

The arrangements stipulate five control points where the machines will check in. These are at Bagdad, Allahabad, Singapore, Darwin, and Charleville. Many of the competitors had contemplated flying non-stop between these points by loading up with as much petrol as they could accommodate, but most of these machines would have been greatly overloaded with fuel and unable to fulfil the conditions laid down. Some controversy resulted from the inability to adopt this plan, and many competitors found it necessary to change their plans and make arrangements for landing at intermediate aerodromes.

One of the difficulties of designers has been to determine whether to fly a very fast machine in short stages, or a slower machine in long stages. Only the results of such a race as this can give an adequate solution to the question, but it is noteworthy that the new Comet, of the De Havilland aeroplane factory, at Hatfield, is a compromise between these two ideas. It is considered that very fast machines need to land more frequently to refuel between the control points, which may cause considerable deviations from the direct route and thus result in much lost time.

Although about sixty-four competitors entered for the race many have dropped out through a variety of circumstances, but less than half that number will take-off from Mildenhall, commencing about 6-30 on the morning of October 20. The race will be international in character, as in addition to English representatives, American, Dutch, French, Italian, Danish, German, and Swedish machines will be flown, as well as representatives from Australia, New Zealand, India, and New Guinea.

British chances in the contest seemed poor, for there was not, when it was announced, any British machine in existence comparable with high-speed standard American air liners. But since the beginning of the year three new British aeroplanes of one type, and one of another type, have been designed and built. These are the three Comets and the Airspeed A.S. 8. All are comparable in speed with the high-speed Americans, and it is probable that the Comet has greater range. Thus Great Britain responded to the challenge, and produced designs in a class which she has hitherto neglected.

The Comet, which successfully passed the Air Ministry's tests, more than fulfils the designer's estimates of performance, and a British victory in the speed division is now by no means impossible. However, it is hoped to prove that British designers can show the world that they possess, in a large measure, the ability to produce a first-class machine capable of flying successfully against the best in the world. Much will, of course, depend upon the skill and foresight of the pilots. The route is a hazardous one, and an error of judgment on the part of any one of them may have a tremendous influence on the result of the race.

Each pilot in the race is participating in pioneering work which will facilitate rapid and safe transport throughout the world, and although all cannot win each is contributing in a feat which will have a far-reaching effect on long-distance flying. It is hoped, however, that nothing will happen to mar the success of the enterprise.

Metallurgical Applications of Vanadium.

THE metallurgical application of vanadium has been well known and amply described in technical literature. The main recent advance, however, has been in understanding and more correctly applying the alloying technique. Vanadium has a strong affinity for oxygen, and, therefore, is capable of reducing the oxides of the ordinary metals. If such oxides are present, dissolved in the metal, the vanadium, prior to alloying, in part deoxidises. This action, however, is different from that of the common deoxidisers, such as aluminium, silicon, titanium, etc. Mr. R. D. Saklatwalla, discussing the subject in a paper presented at the recent meeting of the Electrochemical Society, held at New York City, terms this type of deoxidation "molecular scavenging," whereby the vanadium has gone to a small extent in combination with the oxygen present, and the balance has gone into solid solution in the constituents of the metal formed upon solidification. The part played by the amount combined with the oxygen is entirely different from that of the common deoxidisers. In the case of the latter, the products of deoxidation separate out from the metal, and not being perfectly fluid remain as inclusions in the solidified metal. As far as steel metallurgy is concerned, the lower oxide of vanadium produced by "molecular scavenging" does not separate out as a phase but has the ability to stay in solid solution in the metal grain just as the alloyed metallic vanadium does. This has not only the advantage of avoiding inclusions, but the dissolved oxide affords nuclei of crystallisation performing a "seeding" function which undoubtedly accounts for the fine-grain structure of vanadium steels. This same factor of dissolved oxide influences the diffusion phenomena in the solid state, thus inhibiting grain growth and making heat-treating processes more controllable.

The work of Mathewson, Spire and Samans* on the iron-vanadium-oxygen system indicates that the lower oxide of vanadium produced by "scavenging" can also combine with iron oxide to form a spinel with definite composition, with a different solubility in iron from that of the lower oxides of vanadium alone. Further work along the lines suggested from the results of these authors would be very desirable to enhance our knowledge of deoxidation and grain-growth phenomena.

As a practical result of the above considerations, may be mentioned the recent development of steels with very small amounts of vanadium present. It has been found that very low percentages of vanadium in the magnitude of 0·05 to 0·08% are sufficient to impart grain-size characteristics and consequent properties to commercial steels, even in the presence of large amounts of other alloying elements such as manganese or silicon. This idea has been particularly useful in casting practice where grain-size characteristics are of paramount importance. Associated with grain-growth phenomena are the properties of air-hardening and brittleness which are commercially important from the standpoint of weldability, so prominently demanded to-day of all steels. These low vanadium-containing steels have excellent welding properties. From the same standpoint, such steels also produce physical properties in the normalised state equal to those produced by quenching, which would be necessary if this small amount of vanadium were not present.

A further recent new use of vanadium in steel metallurgy is its application in "nitriding" steels. The vanadium may function there as a catalyser to accelerate the formation of the nitrides. Some development has also taken place in the use of vanadium carbide as the hard element in the newer forms of carbide cutting tools. The addition of vanadium has also been proposed in the manufacture of the 18-8 type of chromium-nickel "stainless" steels to prevent intergranular precipitation of carbides at higher temperatures.

* Trans. Am. Soc. Steel Treating, 20, 357-384 (1932).

Planetarium Screen in Stainless Steel.

The large floating dome for the recently constructed Fels planetarium in the Franklin Institute, Philadelphia, was covered on the inside with 18/8 chrome-nickel stainless steel sheets,* hung from structural members and joined by the shotwelding process. So successful was the result that a similar, but larger, dome has been projected for the Hayden planetarium in the American Museum of Natural History, New York.

The Fels dome is a 65-foot hemisphere upon the interior surface of which the 2,000-odd visible stars are projected in motion from a large stereopticon machine developed by the world-famous Zeiss optical works. As the demonstration proceeds a lecturer explains to the audience various features of position and movement of the heavenly bodies. The dome in reality is a miniature and mechanically controlled night sky, with all details carried out accurately even to reproducing the skyline with its various buildings and stacks in miniature.

Two essentials of the interior surface are high reflectivity and sound deadening properties, the latter to avoid any echo from the lecturer's voice. Exhaustive tests by engineers showed that steel sheets about 1/32-inch thick, and perforated with 4,300 1/16-inch holes per square foot would permit 97% of the sound to pass through to be absorbed by accoustical material on the walls behind, and yet provide a smooth projection screen. Spraying the inner surface of the steel with light-reflecting paint provided reflectivity.

A novel method of stiffening the sheets and suspending the dome, so that when completely welded its 11,000 pounds are practically self-supporting, was evolved. To assemble the dome a jig was designed, consisting of a boom which could be rotated, raised or lowered without changing its radius more than a few thousandths of an inch. On the end of the boom was affixed a welding plate shaped to the curvature of the dome, which located the preformed sheet while the welding was being done from the outside surface.

* Steel. August 27, 1934, p. 28.

Recent Developments in the Electro-deposition of Nickel.

UNDER the above title, Mr. A. W. Hothersall, a well-known authority, discusses the more important advances which have been made in the technique of nickel plating during the last few years. The author deals with the subject under the following headings: Preliminary cleansing procedures; etching treatments for brass, copper, and steel; nickel plating of zinc and aluminium; mechanism of nickel deposition; causes and prevention of pitting in nickel deposits; mechanical properties of nickel deposits (tensile strength and hardness, effect of heat-treatment, hardness and polishing); effects of nickel deposits on resistance to fatigue; throwing power of nickel solutions. The information is arranged to give real assistance to the practical plater and copies of the paper, in the form of a booklet, may be obtained gratis on application to the Bureau of Information on Nickel, the Mond Nickel Co., Ltd., Thames House, Millbank, London, S.W. 1.

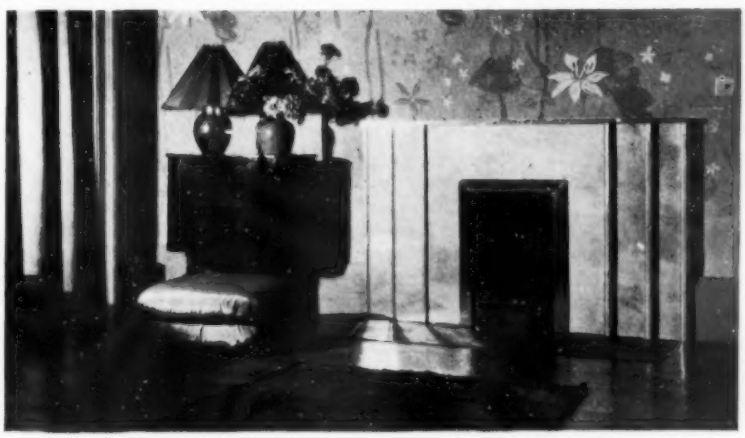
Sands, Clays, and Minerals.

The August issue of the above magazine contains a most interesting part of an early mineralogical pamphlet on Cornish minerals. This part deals with tin ores, and was written by Martin H. Klaproth in 1786, forming part of his valuable paper on "The Minerals and Fossils of Cornwall." Several other articles in this issue will be appreciated—for instance, "Limestones," "Economics of the Carboniferous Rocks," "English Oil Wells," "Methods of Testing China Clay," "Calorific Value of Coal and its Determination," "Australian Pearl Industry," "British Sands and Aggregate Deposits," etc. The issue is well produced and illustrated. It is published by A. L. Curtis, Westmoor Laboratory, P.O. Box 61, Chatteris, England. Price, 3s. 6d. post free.

The Anodic Oxidation of Aluminium and Its Alloys for Protection and Decoration

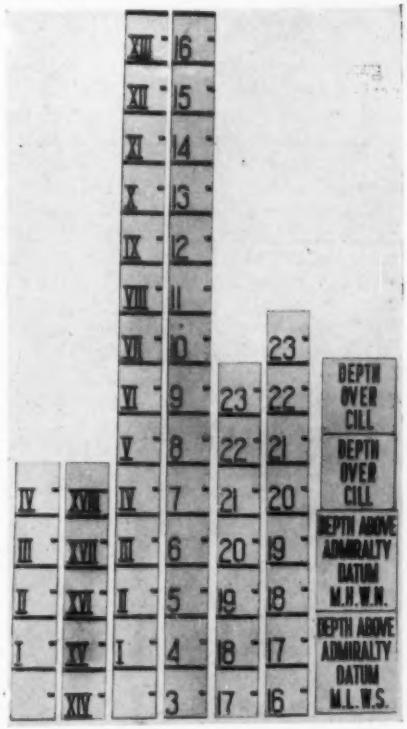
By George O. Taylor.

When aluminium is made the anode in a suitable electrolyte, it becomes coated with a uniform, fine-textured, hard, and adherent oxide film. This provides the basis of a surface treatment, not only for aluminium but many of its alloys, which can be varied to furnish a surface suitable for decoration or protection or a combination of these requirements. In this article the author discusses the many aspects of this process and its variations.



Courtesy of Birmabright Ltd.

Fireplace surround in private house made up from "Birmabright" sheet polished and anodised iridescent. Architect, J. Moore Simpson, A.R.I.B.A.



Depth indicators and noticeboard for the new lock at Southwick, Shoreham Harbour, constructed from "Birmabright" sheet anodised, lanolined and mounted. Letters and numerals cast in "Birmabright," and painted black. Contractors, John Gill (Contractors), Ltd.

THE anodic oxidation process as a means of producing decorative effects and at the same time of improving the corrosion resistance of aluminium and certain of its alloys, is, at the present time, attracting more attention as the advantages it offers are being proved and realised. The moment is opportune, therefore, for a general survey of the process and of the recent developments made in the application of "anodised" aluminium and aluminium alloys in the new fields opened up by the possibility of producing on the metal decorative and utility finishes possessing a high degree of permanence and resistance to corrosive action.

It is now well known that the surface of aluminium normally acquires a thin film of oxide which is practically invisible and yet which exercises a remarkably protective effect, since, so long as it remains intact, further action on the underlying metal is considerably retarded. The object of the anodic oxidation process is the enhancing of this natural film formation by the artificial production of a relatively hard, compact, and tenaciously adherent oxide film offering considerable resistance to certain corrosive influences that might have serious action on the unprotected metal.

The process of anodic oxidation ("anodising") is essentially simple, the article of aluminium or aluminium alloy being made the anode in a solution from which oxygen is released on the passage of an electric current, the oxygen at once combining with the aluminium gradually to produce at the metal surface a film of hydrated aluminium oxide. A large number of solutions have been found capable of yielding more or less adherent oxide films on aluminium anodised therein, including sodium sulphate, ammonium borate, sodium hydrogen phosphate, chromates and bichromates, chromic acid, sulphuric acid and oxalic acid, but the only solutions which are used commercially to any extent are the last three mentioned.

The process which has received the most attention in England is that patented by Bengough and Stuart, utilising for the electrolyte a 3% solution of high purity chromic acid in distilled water. During the past two or three years, however, several companies have been formed for the operation of the process, using for the electrolyte a solution of sulphuric acid with or without the addition of small quantities of other oxidising substances. These processes, which are all developments from the original sulphuric-acid process of American origin are operated under various trade names. The process involving the use of oxalic acid for the electrolyte is of German development, but is little known in this country.

Procedure of Anodic Oxidation.

The actual operation of anodising is similar to that of plating. Just as chromium may be deposited either bright for decorative purposes or dull for utility purposes, so may material be anodised for decorative or utility purposes. The oxide film formed on surfaces polished prior to treatment is smooth and glossy, and is thus both decorative and protective, while the film formed on the normal surface of wrought or cast material is suitable only for general utility purposes, since it has little decorative value.

After any necessary pre-treatment of the metal surface, therefore, the material is thoroughly degreased and

suspended from the anode bus-bar into the anodising solution, either by means of a stout aluminium wire tightly attached by binding, or by means of a special rack or clip designed for the purpose.

The times of treatment and anode voltages applied vary in the two processes as follows :—

Chromic Acid Process.—The temperature of the solution is maintained at 40 ± 2° C. The maximum commercial thickness of oxide film is produced in one hour, which is regarded as the standard time of treatment. During this period the anode voltage may be raised gradually to 40 during the first 15 mins., maintained at 40 for 35 mins., raised to 50 in 5 mins., and held at 50 for the last 5 mins. For the production of certain decorative effects, however, the time of treatment is lessened to between 10 and 30 mins.

Sulphuric Acid Process.—The temperature of the solution is maintained generally at about 20° C., but for special purposes may be higher. Similarly, the concentration of acid is usually about 10%, but may be as high as 70%, since one of the main features of this process is that it is possible to vary the hardness and ductility of the oxide film by manipulation of these factors. The anode voltage is held constant, usually at 10–15 volts. The standard time of treatment is from 30 to 60 mins.

General Properties of the Anodic Film.

(1) The maximum commercial thickness of oxide film produced after 1 hour of treatment, is about 0·002 cms., which is estimated to be at least one hundred times thicker than the film resulting from natural oxidation.

(2) The film is integral with the metal, and will not peel, chip, or flake, since it is formed not by deposition but by conversion of the metal surface into oxide.

(3) Although it is extremely hard and resistant to frictional abrasion, the film may be scratched with a sharp metal point because of the " give " in the softer underlying metal.

(4) When freshly formed, the film is of a microscopic cellular structure, and possesses the property of absorbing colouring matter and greases which are more or less permanently bound.

(5) Freed from moisture, the oxide film possesses a good insulating property, which may be further improved by impregnation with synthetic resins or waxes, when the dielectric value may be increased to withstand voltages up to 2,000.

(6) When impregnated with a grease such as lanoline, or a good wax, the film has very considerable resistance to atmospheric and sea-water action and to certain chemical substances which might attack the unprotected metal. The precise degree of resistance depends on the constitution of the anodised material.

(7) The film acts as an excellent bond for painting materials, which are partially absorbed, and thus firmly anchored to the metal surface.

(8) The formation of the film is not dependent on the throwing of the power of the electrolyte, and it is produced on all places to which the solution can penetrate.

Alloys Suitable for Treatment.

Unfortunately, not all aluminium alloys are suitable for anodic oxidation treatment, and it is a fact that those alloys which least require protection are those most amenable to the process. Briefly, in addition to pure aluminium it is possible to treat with varying degrees of success most of the alloys at present available with the exception of certain copper and zinc bearing alloys which require special consideration. Alloys containing over 5% of copper are not suitable for treatment by the chromic acid process, but it is possible by the sulphuric acid method to anodise alloys containing up to 9% of this metal. The limiting zinc content is not clearly defined, but material containing 12% of zinc can be successfully treated in both wrought and cast forms by both processes.

The alloying constituents of the metal control also the natural colour of the oxide film. For instance, the films produced on silicon-bearing alloys vary in colour from a light bluish tint to a dark slate colour as a function of the increasing silicon content, while the copper and zinc-bearing alloys yield films of different shades of opaque greyness. Alloys forming such self-coloured films are of little use for decorative purposes, but the pure metal and the aluminium-magnesium alloys yield films possessing a definite degree of transparency and are, therefore, ideally suitable for the production of anodised metalwork for architectural purposes.

Although the range of alloys which can be treated is thus fairly large, it must be taken into account that where the treatment of large batches of articles is contemplated the choice of the alloy has considerable bearing also on the cost of treatment, since, assuming the labour involved and the time of treatment as being standard, the cost is determined chiefly from the current consumed. Thus, whereas certain cast copper-bearing and zinc-bearing alloys may require a current of 100–150 amperes per sq. ft. of surface to produce the necessary anode voltage — a cast aluminium magnesium alloy may require as little as 8 amperes per sq. ft., and the cost of treatment is comparatively very small.

Another important point which must be borne in mind in choosing an alloy for anodic treatment is that, although the oxide film enhances the corrosion resistance of any alloy, the resistance is relative to that of the unprotected metal. Thus, for an application involving continued or intermittent contact with seawater or hard water, the corrosion resistance of an anodised copper-bearing alloy would still not be so good as that of an unprotected alloy specially evolved for high resistance to corrosive action, such as may be found in the aluminium-magnesium alloy series.

Production of Utility and Decorative Finishes.

Pre-treatment of the Surface of Wrought Material.—The preparation of the metal surface before anodising is analogous to the procedure followed in plating, the pre-treatment given depending on the type and function of the finish desired. Where it is desired only to enhance the resistance to corrosive action, no treatment is necessary, and the material may be anodised directly on the degreased natural surface. The majority of decorative finishes are produced on material that has been polished, the film obtained being smooth and glossy. Quite pleasing bright matt finishes, however, can be achieved on a surface which has been scratch-brushed or sanded after surface grinding.

Especial care must be exercised in polishing, as the anodising process definitely accentuates any defect existing in the metal surface. For instance, with articles made by spinning, it is necessary first to grind sufficiently deeply to remove the concentric marks left by the forming tool, since, if the surface is merely mop polished, although these marks may seem to be removed, they become plainly apparent after anodising. Similarly, if good results are to be achieved on rolled sheet or extruded sections, it is essential to grind to remove scrape marks or score marks left by the die.

Considerations on the Treatment of Castings.

The treatment of castings for decorative purposes presented many difficulties in the early development of the process, partly because the limitations of the various alloys were not thoroughly understood and partly because it was not known how to prevent unsightly staining of the surface, due to the exudation of absorbed electrolyte from the pores of the metal after the treatment. It is now possible, however, by a simple de-staining process conducted after the anodising treatment, to remove effectively the absorbed electrolyte.

By utilising a casting alloy specially suitable for the work, beautiful effects may be produced with the same facility as on wrought material. Castings made in gravity dies are, in general, more amenable to treatment than sand castings, as the structure of the metal is closer, but

if care is exercised in the making of castings in sand moulds good results may be achieved. Pressure die castings are definitely not suitable for treatment for decorative uses, since the exfoliated structure and entrapped oxide caused by the rapid chilling of the metal are visible after anodising however deeply the article may be ground prior to treatment. Whatever the form of casting considered, especial care must be taken to avoid porosity and entrapped flux, and any factors likely to contribute a coarse structure to the metal should be controlled.

It is not possible to treat castings having inserts of metal other than anodisable aluminium alloy, since the current concentrates at these points to cause local corrosion of the metal surrounding the foreign body. In polishing, the usual procedure is followed, all surface holes being ground out wherever possible.

Types of Decorative Finishes Available.

(*a*) *Chromic Acid Process.*—Three finishes of quite different appearance are attainable. These are :—

(1) Iridescent : Transparent film with iridescent colour reflection. This finish is suitable only for interior use under which conditions it is quite stable.

(2) Antique Silver : Transparent silver-grey appearance. Material so treated is soft and pleasing in tone, and suitable for both interior and exterior use. If used out of doors it must be cleaned occasionally with a wax polish to preserve it in good condition.

(3) Full Grey : Semi-transparent dove grey enamel-like appearance. Suitable for both interior and exterior use. Under outdoor conditions the finish is remarkably stable, and can be permanently preserved by dressing every few months with wax polish. It is extremely resistant to sea-water action.

The silicon-bearing alloys will not yield these finishes, and the films produced on the copper or zinc-bearing alloys tend to opacity and drabness.

(*b*) *Sulphuric Acid Process.*—The plain finishes given by the sulphuric acid process range from iridescent to shades of silver. The silver finishes may, by careful control, be produced either bright with semi-transparent appearance, or bright with frosted appearance, and are suitable for both interior and exterior application. When used outdoors occasional dressing is necessary to preserve the bright appearance.

Impregnation of Plain Finishes.

Finishes produced by the chromic acid process are improved in brightness by dressing with a good wax polish or grease immediately after treatment, in the case of wrought material, or after destaining in the case of cast material. Such impregnation with greases is also of great advantage in improving the weathering properties, since it is absorbed into the film, and although not apparent it renders the surface waterproof and stainproof.

Material anodised by the sulphuric acid process is more generally impregnated by a process known as "sealing," the anodised material being immersed in boiling water containing in suspension an insoluble inorganic salt, such as barium sulphate. The suspended salt is mechanically carried into the film to fill in the cellular spaces and render the oxide deposit dense and non-absorbent. This generally has a clouding effect.

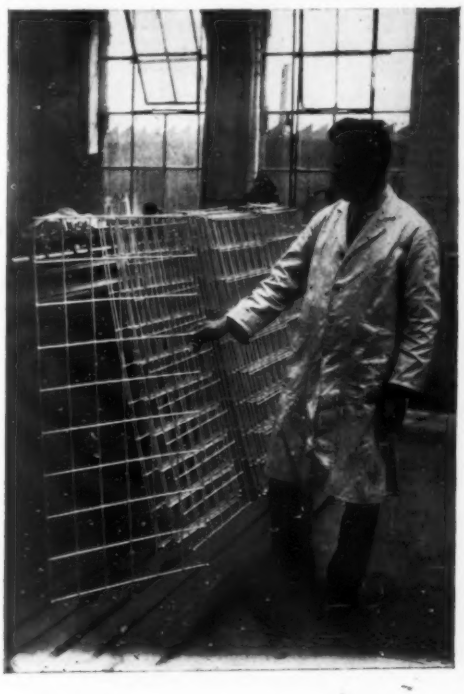
As might be expected, anodised material impregnated either with grease or by "sealing," possesses a resistance to corrosion greater than that of non-impregnated material, hence it is the standard practice always to treat the film by one or the other of these methods.

Coloured Finishes.

Freshly anodised, non-impregnated material possesses a remarkable capacity for the absorption of colouring matter, which is permanently retained within the film with the production of a smooth, bright coloured effect. The operation of colouring may be carried out either with organic dyestuffs, or by the precipitation within the film of a coloured insoluble metallic salt. The colouring with organic dyestuffs is analogous with the dyeing of cloth, the metal being immersed in a hot dye solution till the desired depth of colour is attained. It is possible to produce practically any shade in pale or dark colours by this means.

Colouring by inorganic precipitation is less simple, and involves first immersing the anodised metal in a solution of one inorganic compound and then in a solution of another, which will react with the solution already in the film to precipitate therein a coloured compound. The range of colours available by this method is comparatively limited, but the coloured effects so produced are claimed to be more stable than those produced with organic dyestuffs.

The material is, after colouring, always impregnated with grease or by sealing, to render the film waterproof. In general, coloured material is suitable for interior use only,



Aluminium grids anodically treated to withstand corrosion when used in strong acids.

Courtesy of the London Aluminium Co., Ltd.

as the effect of the atmospheric acids and rainwater gradually bleaches the colour. Even for interior uses it is essential that all colouring materials used should be fast to light and heat, otherwise gradual fading of the finish may occur.

Practical Application of the Anodic Oxidation Process.

In Architecture and Decoration.—Anodised material is finding increased favour for architectural metalwork, the soft, yet pleasing, finishes available blending readily with many decorative schemes where the yellow metals or bright steels would be in discord, while the uncommon appearance of the iridescent, antique silver and coloured finishes provide the architect with a welcome relief from the cold brightness of the polished metals. The smoothness and hardness of the finishes render the material especially suitable for interior decorative metalwork not readily accessible for cleaning purposes, and in such applications no further attention is necessary than an occasional wiping to remove the normally collected dust. Even under exterior atmospheric conditions the adhesion of dirt is so slight that any necessary periodic cleaning may be carried out in the minimum of time. Moreover, there is no danger of surface blistering or peeling such as may be encountered with plated metals.

The use of the coloured material in the form of fillets and strips for the relief of plain metalwork has many advantages over the use of enamelled wood or metal, since, being integral with the metal surface, the colour cannot be accidentally chipped or flaked to cause an unsightly exposed area of the base material. Door furniture, such as lever-handles, kicking plates, finger plates, and push-bars made from wrought and cast aluminium alloy, are very effective, and are becoming increasingly popular in substitution for brass or bronze fittings.

In Industry.—The applications of the anodic oxidation process are now so varied that it is not possible to give more than a brief outline of the many uses to which it has been put. Heat-treatable alloy material used in the construction of aircraft has, for some years, been anodised on a large scale to take advantage of the high corrosion resistance and paint adhesion properties conferred, as have also alloy parts required to operate under marine conditions or in hard alkaline water.

Automobile fittings and cycle parts are treated for decoration, wear resistance, and protection, and it is interesting in this instance to note that one well-known American automobile incorporates a radiator grille of heavy gauge aluminium sheet stamped out in one piece and anodised to a matt silver finish by the sulphuric acid process. Cycle handlebars and seat pillars in heat-treatable alloy, anodised and coloured, have recently been introduced in this country, and the attractive appearance and saving in weight effected should render them a popular accessory. Numerous novelties and fancy goods are being produced by stamping from sheets already processed and coloured, the saving in cost over individually plating each article so produced being quite considerable. The latest development is in the production of reflector bowls having a reflecting efficiency higher than that of the bright polished metal, but which, unlike the unprotected metal, do not appear to lose this power even on prolonged exposure outside. Thus, every day more and more fields of use for aluminium and its alloys are being developed, and the material is now employed where, a few years ago, it would have been considered unsuitable.

The author desires to acknowledge his indebtedness to Mr. G. W. Lacey, B.Sc., A.I.C., for various suggestions in the preparation of this article.

Technical Education in Great Britain. Management Congress,

The subject of management as a separate and distinct factor, has not, perhaps, received the attention it deserves. It is important therefore to note that the Sixth International Congress for Scientific Management is to be held in England for the first time in July next year. H.R.H. the Prince of Wales has consented to be patron, and the chairman will be Sir George Beharrell, D.S.O., the managing director of Dunlops. The Council of the Congress consists of some 60 leading professional and scientific bodies, including the Industrial Transport Association, several of the engineering institutions and the Institution of Automobile Engineers.

The subjects for papers have been chosen with a view to obtaining discussion of practical applications of scientific management in all its phases. These include the manufacturing section which is concerned with budgetary control and the technique of works management. Amongst those contributing papers under this head is C. R. F. Engelbach, production manager of the Austin Motor Company.

The Congress will appeal to all those holding managerial positions in any phase of our national life, but it is a further object of the Congress to arouse a more public interest in the subject of management. At the Paris Congress in 1929 over 2,000 members were enrolled, and this number may well be exceeded next year, as 600 delegates are expected from abroad. A feature of the arrangements of the Congress will be the visits to factories, farms, and other places of interest, by which it is hoped to show the international delegates that there are in this country many examples of highly-skilled organisation. Full information regarding this Congress may be obtained from Mr. H. Ward, 21, Tothill St., London, S.W. 1.

ELECTROSTATIC TAR SEPARATION.

FOR the separation of finely divided tar, as well as dust and water particles, from coke-oven gas, blast-furnace gas, air, or any other gaseous medium, the great value of the electrostatic method is now being widely recognised. In by-product coke-oven practice, and the same applies to town's gas, it is familiar knowledge that a comparatively large amount of finely divided tar particles have to be removed from the cooled gas before scrubbing for light oil.

The " P and A " separator and the " Livesey " washer, although excellent in many respects, with a long record of good service, do not remove all the finer particles. Also they have a number of other disadvantages, especially high-back pressure, up to 8 in. W.G. emulsification of the tar, and fairly high maintenance and operating costs.

In this connection the electrostatic method, especially according to the " Lodge-Cottrell " system, is of great importance, one of the main advantages being the very high efficiency of the tar removal. When carried out according to the more usual practice in the cold condition, that is with the gases cooled to 77°—86° F. after passing the primary and secondary condensers, the efficiency is over 99% in actual continuous performance, much superior to any other method.

A large number of electrostatic plants, for example, are now operating in Great Britain and the United States on coke-oven gas, and the standard performance guarantee is 99% removal, plus or minus 1%, involving also the removal of water particles. The back pressure is negligible, about $\frac{1}{8}$ in., and the saving in fan power compared with other methods is usually more than the total power required to operate the electrostatic method. Also the complete removal of the tar prevents thickening of the gas oil used in scrubbing for light oil; this alone representing a considerable economy, while the tar separated by electrostatic methods shows little trace of emulsification and separates from water almost immediately. If necessary, however, electrostatic " detarring " can be carried out in the hot condition, treating the gas at, say, 175° F. from the primary cooler.

It will be remembered the basic principle of electrostatic precipitation is the use of plates or pipes, constituting a series of earthed collector electrodes. In the narrow spaces between these plates or in the pipes hang wires or rods with numerous points, forming discharge electrodes, which are coupled to high-tension, direct-current supply at 60,000—70,000 volts, so that brush discharge takes place. As a result the dust particles in the gases which pass through the ducts or pipes are electrified and repelled against the earthed collector electrodes, which are equipped with motor-driven rapping hammers and plant of this type, as supplied by Lodge-Cottrell, Ltd., is being used extensively for many applications, especially also blast furnaces on the latest two-stage system of cleaning, over 3,000 electro-filters being now at work.

Valves for handling corrosive substances have received a good deal of attention in recent years, and many tests have been made, under both laboratory and works conditions, in an endeavour to find a material with improved life at reasonable cost. Very good service has been obtained with austenitic nickel alloy cast irons of the Ni-Resist type, and some interesting results are available from America.

In one instance a valve of cast iron of the Ni-Resist type, used in contact with sulphuric acid (58—66° Baumé) in a fertilizer plant, was still in good condition after fourteen months' use, ordinary cast iron and bronze valves having failed after only a few weeks. Again, a Ni-Resist valve, used in an oil-refinery for handling heavy acid sludge at about 90° C., was found to be in excellent condition after twelve months' service, ordinary cast iron valves having had a life of from three weeks to three months.

The Technical Basis of Soviet Industry

By a Russian Correspondent.

It is becoming increasingly recognised that progress in industry is dependent upon the application of science, not only in the primary materials employed, but as fundamental in the many and varied processes necessary in giving the finished product the required characteristics and quality. It is not surprising, therefore, that in the plan for industrialising Russia, the application of scientific research is one of the foundations on which the U.S.S.R. is building. The development of this branch of industry is briefly reviewed by our correspondent.

THE systematic application of science to the processes of production has become one of the foundations of Soviet industry. In this a great part is played by the scientific research institutes, formed in every branch of the national economy scheme organised by the U.S.S.R.

The most widely developed network of scientific institutions is possessed by the heavy industries. These institutions are divided into two main categories—the so-called capital institutes under the direct control of the Commissariat of Heavy Industries, and the branch institutes controlled by the administrations of the particular branch of industry concerned. At the beginning of the present year the total number of scientific institutes functioning in the heavy industries was 121. They are divided among the different branches as follows :—

	Scientific Institutes.	Affiliated Branches.	Total.
Physics (including optics)	6	—	6
Electrotechnical	6	—	6
Energetics	7	1	8
Fuel	5	4	9
Ferrous metallurgy	6	—	6
Non-ferrous metallurgy	5	—	5
Machine building	16	1	17
Chemicals (including coal chemistry)	28	6	34
Ore-mining industry	5	11	16
Building (including building materials)	20	4	24
Surveying institutes	4	1	5
Geology and geodosy	6	2	8
Compound industrial institutes	7	—	7
Total	121	30	151

Most of the scientific research institutes in the heavy industries are in the R.S.F.S.R.—that is, in Russia proper, and the largest of the federal republics of the Union. The R.S.F.S.R. now has 93 institutes, 51 of which are in Moscow and 22 in Leningrad ; the Ukraine has 17, 11 of which are in Kharkov ; the Central Asiatic republics have 5, Transcaucasia 5, and White Russia 1. The number of workers engaged in the entire system of research institutes for the heavy industries is 34,200, of whom 10,000 are scientific workers.

The scientific base of the heavy industries is not only growing in quantity, but in quality also. As a result of the work of the institutes, numerous complex technical problems have been solved in industry. It is sufficient to enumerate only some of the most important of them : Work in aluminium (as a result of which several processes have been completely mastered by industry), work in various kinds of special steels, in titano-magnetites, in synthetic rubber, several processes in the gasification of oil, new effective installations in the cracking process, the construction of new types of aeroplanes and motors, etc.

The work of the institutes is strictly planned. A concrete example of this is the conference of planning scientific research convened in the spring of last year in connection with the tasks of the second five-year plan. Some of the leading scientific forces of the country took part in that conference, at which the pivotal problems of the second five-year plan were worked out. The different institutes based their annual plans of research for the period 1933-34 on the findings of that conference.

The work of the institutes is closely bound up with the units of production. They conclude economic agreements with the works and factories, they send brigades of scientific workers into the industrial enterprises for the solution of particular technical problems. Eighty-two of the institutes are attached to 300 enterprises for the purpose of systematic scientific service. A number of the institutes have their own experimental plants, workshops and factories, which are increasing from year to year.

The fact must be mentioned that the work of a number of the institutes, in its scope and importance, has received recognition beyond the confines of the U.S.S.R. World recognition has been accorded to Soviet institutes in the field of physics, chemistry, geophysics, geology, etc. Soviet scientists take part in all important world scientific congresses and conferences, many of which are convened in the Soviet Union.

The scientific-technical base of Soviet industry is not limited only to the institutes. In recent years, all the big industrial enterprises have organised laboratories of their own, and these play a prominent part in the productive processes. One such laboratory has been organised in the Moscow ball-bearing works " Sharikopodshipnik," another in the Kharkov Tractor works, and in the Ural Machine Building Works, the Stalingrad Tractor Works, the Kuznetsk Metallurgical Works, etc. Some of these laboratories have acquired reputations in the Soviet Union as first-class institutions of scientific research, such, for instance, as the laboratory in the Leningrad works " Svetlana."

The laboratories fall into three categories : The general works laboratory, the shop laboratory, and the express laboratory (for quick analysis). The works laboratories control all the technical processes in every stage from raw material to finished product. They are also responsible for the regime linking all the productive processes on the technical side.

All industrial enterprises have technical libraries, which are used, not only by the scientific and technical personnel, but by the workers as a whole. The 1,800 registered factory libraries in the heavy industry at present possess five million volumes. The central library of the Commissariat of Heavy Industries is a rich store of technical books both of the Soviet Union and of foreign countries. In addition to the libraries, other institutions of importance in the technical improvement of the processes of production are the consulting cabinets and technical exhibitions. Sixty-seven of the machine-building plants in the Soviet Union have 67 permanent exhibitions, about 100 temporary exhibitions, 135 travelling exhibitions, 12 technical consulting cabinets, and 21 shop consulting cabinets. The Donetz and Moscow coal basins have a number of technical stations ; Baku, the centre of the Azerbaijan oil industry, has not only technical stations, but a geological museum. Great popularity in the respective industries are enjoyed by the exhibition of Soviet shipbuilding (in Leningrad), the exhibition for the utilisation of waste (also in Leningrad), the exhibition for the production of aluminium (in Denieprepetrovsk), the exhibition for the boring, raising, and refining of oil (in Baku), the exhibition of precision instruments (in Moscow).

In some towns the industrial exhibition has gradually grown into the " House of Technics," around which are grouped the foremost scientific-technical forces. Mention must not be forgotten of the extensive work in technical education carried out in the works and factories. This

sometimes takes the form of technical study groups for the improvement of qualification of the workers, consultations with specialists, facilities for worker-inventors, and rationalisers to do their work, etc. To master the modern technique of production has become an urgent need with the mass of workers in the U.S.S.R., and in this they are greatly helped by the extensive network of scientific institutions forming the scientific-technical base of Soviet industry.

Molybdenum.

Molybdenum owes its importance primarily to its value as an alloying element in steel. Its functions are essentially to exert a powerful influence in improving the physical qualities, in promoting fine grain structure, in eliminating temper brittleness, in reducing the effect of mass, and in giving permanency to the physical properties which enable the steel to resist abnormal conditions during service and when subjected to wide temperature variations. This mineral is discussed by Sanderson,[1] who states that the name "molybdenum" is derived from "molybdos," a Greek word, the meaning of which is "lead." It is a metallic element, with an atomic weight of 96·0, specific gravity of 8·6 to 9·0, and a melting point about 2,500° C. In appearance the ore has a likeness to graphite, having a bluish tinge and high density. In the pure condition, it is a silver-white metal, and is comparatively soft, fairly malleable when hot, and ductile. The addition of carbon makes it much harder. Metallic molybdenum is usually impure owing to the absorption of carbon. It is, in this condition, grey, brittle, and hard enough to be capable of scratching steel. Exposure at ordinary temperatures does not perceptibly change it, nor is it readily dissolved by acids. Not until 1906 was it found possible to draw it into wire. As wire, its tensile strength is about half that of tungsten steel wire of the same diameter. Its extraction was first accomplished in 1782 by Hjelm. Usually it is found in association with acid rocks, such as granite, but it is also quite often found in quartz lodes and pegmatite dykes that spring from acid intrusive masses. It occurs in comparatively small flakes, embedded in quartz reef, or distributed through granite or pegmatite.

The principle ore of molybdenum is molybdenite (MoS_2), which contains approximately 60% of metallic molybdenum. Other ores are wulfenite ($PbMoO_4$) and molybdite (MoO_3). Wulfenite is a yellow or reddish tetragonal mineral, and molybdite, an earthy yellow powder. There is also a yellowish oxidation product known as molybdic ochre (hydrous ferric molybdate). These ores do not occur in profusion in any one spot, but are fairly widely scattered throughout the globe. During the war, the serious shortage of tungsten produced an increase in the demand for molybdenum, which fulfils largely the same purposes as tungsten. As a result, there was a general opening up of new fields, particularly in the United States of America, Australia (Queensland and New South Wales), Canada (Quebec), Norway, Japan, and Sweden. These countries are given in the order of their productive importance measured in tons of metal produced in 1918; but the available figures are by no means trustworthy, and do not show the comparative standards of metal concentrate produced.

When used for light duty, such as drawing thin sheets with light draft and full curves, as for example, bodies and fenders for light cars, cast iron dies of the following composition have been recommended: Total carbon, 3·00 to 3·40; manganese, 0·60 to 0·90; phosphorus, under 0·30; sulphur, under 0·12; silicon, 1·25 to 1·75; nickel, 1·25 to 1·75; and chromium, 0·50 to 0·75%. The silicon and chromium should be varied according to the thickness of the dies.

1 L. Sanderson: Sands, Clays and Minerals. Vol. 2. No. 11, 1934.

The Use of Barium Flux in the Electric Furnace.

As a result of experiments[1] carried out in a Detroit rocking furnace, with various ferrous metal heats, it has been found that the addition of a mixture of barium oxide and barium carbonate, about half an hour before pouring, not only improves the metal product but adds greatly to the life of the acid lining of the furnace. Many different salts of barium were tried, and after considerable investigation it was found that a mixture of natural barium carbonate (witherite) with a 10 to 20% addition of a special fused barium oxide was the proper material to give the most efficient reproducible results.

It is claimed that when this barium flux is added to an electric furnace it protects the acid lining, preventing spalling and disintegration. In gray and high-test cast-iron melts this flux prevents absorption of silicon from acid linings and slags. It acts as a scavenger, and frees the metal from inclusions. For white cast irons, including those commonly used to produce malleable iron mixtures, the barium addition shows improvements in the properties of the metal and renders it less susceptible to absorption of mould gases and metal oxides. Added to low-carbon steel melts, definite improvements in the properties of the metal have been recorded. Upon addition to high sulphur bearing ferrous alloys the sulphur content is appreciably reduced.

The barium flux will condition the atmosphere of an electric furnace, sustaining the arc and cleaning and quieting the metal, and also condition slags in certain types of electric furnace, making them less viscous, preventing slag inclusions in the finished castings and preventing slag adherence to the walls of the furnace.

World Tin Statistics.

The September issue of the Bulletin from The Hague Statistical Office of the International Tin Research and Development Council, shows that in the first seven months of 1934, "apparent" world consumption of tin has been 68,641 tons, compared with 71,106 tons for the same period in 1933.

These figures must not be taken as a comparative measure of actual consumption during these periods because, since the beginning of this year, as the Bulletin shows, "invisible" or consumers' stocks have been reduced in the United States by some 8,000 tons, which has passed into consumption.

An indication of actual tin consumption in the U.S.A. is given in the following table:—

Tin Consumption, U.S.A., January to July. Long Tons.

	1933.		1934.
Tin in tinplate	13,920	..	14,050
Tin in babbitt	1,610	..	2,130
Tin in solder	4,160	..	5,630
Tin in bronze, foil, and collapsible tubes	5,730	..	6,560

The better demand is largely accounted for by the improvement in automobile production which, during the two periods under review, accounted for just over 2,000 tons increase.

World production of automobiles in the twelve months ending July, 1934, amounted to 3,604,000 units, compared with 2,328,000 units during the preceding twelve months.

Tin consumption by individual countries is given in the following table:—

Twelve Months ended July. Long Tons.

	1933.		1934.
U.S.A.	46,519	..	52,046
U.K.	18,368	..	20,915
Germany	8,824	..	10,788
France	10,027	..	9,466
U.S.S.R.	3,390	..	4,933
Italy	3,692	..	4,000
British India	2,017	..	2,000
Total	92,837	..	104,148
Total World	110,221	..	124,800

1 M. A. Baernstein, Reprint, 66-19. Electrochemical Soc.

Some Notes on Manganese in Straight-Carbon Steels of Hardening Quality

By Glyn Powis

Theoretically, a carbon steel should harden on suitable quenching, the degree of hardness obtained depending upon the amount of carbon present; in practice, however, it is found that the percentage of manganese, present in the steel, has an influence on the degree of hardness obtained, and it is suggested that the content of this element should be between definite limits.

IT is probable that at least one-half the people who buy ordinary commercial carbon steels do not specify a manganese content, and that of the remainder there are a fair proportion who specify the element from an "as before supplied" attitude of convention rather than any particular desire to reap the advantages to be gained by ensuring the presence of a definite minimum and maximum amount.

Manganese, in steel, is an element around which centres much controversy. While academical thought is inclined to be content with the text-book exposition that the transformation points are lowered and merged together by its presence, the practical man is compelled to take a more detailed account of its several effects. "Compelled" is used advisedly inasmuch that a substantial variation in manganese content appears to affect the quenching propensities of a steel to a greater extent than it should in theory, and only practical experience can be of service in many instances.

Theoretically, a carbon steel should harden on quenching suitably, the degree of hardness obtained depending upon the amount of the element present. The correct hardening temperature should be as shown on the Fe-C. diagram plus the generally-accepted allowance of the few degrees to offset the fall of temperature which occurs during the transference of the material from the heating chamber to the quenchant.

Some well-known manufacturers of heat-treatment equipment supply temperature recorders for operation in connection with hardening furnaces. These recorders indicate what is regarded as the correct hardening temperature by showing as an inflection on the heating curve the point where solubility of the pearlite in the ferrite becomes complete.

It would appear, then, to be a simple matter to adopt one or other of these two means of finding the correct hardening temperature for a steel of any given carbon content. But the former means, that is, the Fe-C. diagram, answers for straight-carbon steels only, and allowance needs to be made for manganese in any quantity. The recorder method is, of course, ideal owing to the fact that the correct point is shown regardless of the presence of other elements. Unfortunately, however, as indicated earlier, using a few degrees above the carbon change point as the correct temperature for quenching may not always result in satisfactory work where the manganese content is likely to vary to any great extent. Where great accuracy is desired, it is advisable, therefore, that attention be paid to the amount of manganese present in conjunction with the carbon.

It is probable that these remarks will be incredible to many, so that, in order to stem the rising tide of criticism which it may provoke, just one example of many is selected for reference here to provide some little food for thought.

For the manufacture of small shear blades, a supply of crucible cast steel was obtained from a Sheffield manufacturer. The purchaser concerned was not equipped with a laboratory at the time, and the material was, therefore, bought as being "suitable for the manufacture of shear blades." The section was not a heavy one, as shear blades go, being only 5 in. × $\frac{7}{8}$ in. in dimension; nevertheless, after making the blades, it was found impossible to obtain a degree of hardness in them any greater than one would expect from a 0·35% carbon steel—and this after quenching in water.

On making investigations, it was found that 0·90% carbon was present which the suppliers claimed as being perfectly satisfactory. Theoretically, a blade of the section mentioned containing 0·90% carbon should have hardened quite satisfactorily on quenching in water from, say, 760° C. But this it would not do in practice, in fact, even quenching from 900° C. failed to produce a hardness sufficient for the purpose required. It was obvious that something was seriously amiss, and further analysis revealed it to be low manganese. A content of 0·07% of this element was recorded—probably approaching a record in this direction—and it was obviously the reason why hardness was not obtainable. Here, then, is a case where the normally-expected functioning of a given carbon steel is completely upset by the fact of the manganese being abnormally low.

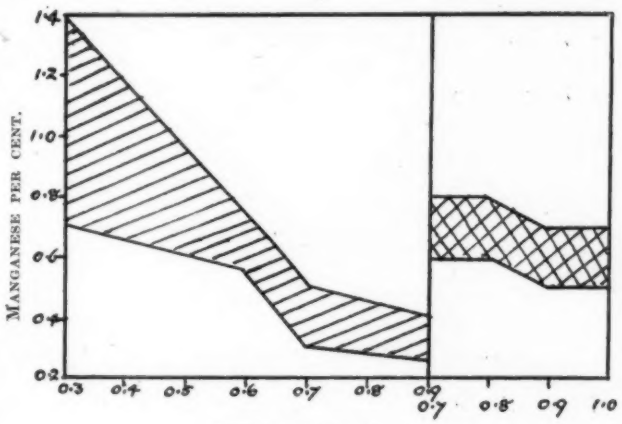


Fig. 1. *Fig.* 1*a*.

Before elaborating on the main object of these remarks, a simple test is suggested for the sceptically minded. Obtain two pieces of steel, preferably plates, as these provide a bigger surface for observation purposes. See that both are exact as to measurement and type of manufacture. Choose a carbon content, say, between 0·50% and 0·80%, and see that both plates contain exactly similar amounts of this element. For the manganese, however, one plate should contain between 0·40/0·50% more than the other, *e.g.*, 0·50% manganese in one plate, and, say, 0·95% in the other. Heat both to a suitable hardening temperature, and quench in water in a manner which will enable observation to be made while cooling progresses. A convenient way of doing this is by gripping with a pair of tongs. It will be noticed that the low manganese material retains its red-heat for a perceptible time longer than the higher one, and will also be less hard when both are finally quenched. This is practical evidence of quenching being retarded, and explains why a low manganese steel is difficult to deal with.

Having indicated that manganese variations can introduce conditions into steel hardening which are not completely dealt with under theoretical considerations, the

writer proposes to discuss the influence of manganese in various straight-carbon steels of hardening type, as found by him in the course of some years of practical experience in hardening.

To simplify the description Fig. 1 shows in diagrammatic form the range of manganese content which usually yields the best results in conjunction with various carbon contents. The diagram is shown in two separate sections, the section Fig. 1A being dealt with separately at a later stage.

In the first place it must be realised that no hard-and-fast rule can ever apply to the maximum or minimum amount of manganese permissible for any given carbon content inasmuch that there are so many and variable factors always operating in steel hardening. Suffice it to say that there are instances frequently recorded of successful results obtained with steels having manganese in amounts outside the recommended range. Such successes have been found by the writer to be more of an incidental nature than a regular occurrence and the diagram is only intended to indicate what combinations are most likely to give satisfactory results with fair regularity.

Generally speaking, where the articles to be hardened are of a nature which allows of water quenching, the lower ranges of manganese will usually operate. The higher percentages of manganese are most suited for oil quenching, while the middle of the range may be quenched in salt baths. The quenchant employed, however, will always depend on the mass of the object and the degree of hardness to be obtained in addition to the percentage of carbon.

With steels between 0·30% an 0·40% of carbon manganese may vary fairly considerably. Those containing the latter element below 1·0% are usually quenched in water, unless the sections are very small. Those steels with 1·2 to 1·4% manganese produce a high resilience on oil quenching, but in neither instance is there very great need for close control of the element.

From 0·40 to 0·50% carbon the range of manganese advisable in conjunction diminishes rapidly. From 0·50 to 0·60% carbon the risk of quench-cracks if water is used is very real. Even if the mass is such as to preclude the possibility of complete hardness penetration surface cracks will often occur. The manganese must, therefore, be either kept low or a milder quenchant be employed.

Above 0·60% carbon the range of manganese falls rather abruptly, as well as narrowing down from 0·20 to 0·15% in width as 0·90% carbon is reached. Steels approaching eutectic composition require less assistance from the manganese in order to obtain hardness on quenching, although, as mentioned earlier, there is a definite minimum to which one may go in this direction. Salt or oil should be used for quenching these types of steel whenever sections will at all permit.

With steels of approximately eutectic composition high manganese appears to coarsen the texture of the structure which, as might be supposed, results in increased brittleness in the quenched product.

In Fig. 1A is shown an entirely different range of manganese content for steels of approximately eutectic composition. These particular steels are used for the manufacture of heavy springs of both coil and laminated types, partly because of the difficulty in getting a sufficient depth of hardness on oil quenching, and partly because even though the centre may remain pearlitic after quenching, the high manganese imparts a certain amount of resilience even in the unhardened state, and so produces a stronger spring than one of similar carbon, but lower manganese in a similar state of hardening penetration. It is probably correct to say, however, that should the section be one which allows of complete penetration of hardness with a manganese content as given in Fig. 1, then the article would be generally inferior, if made of material with the Fig. 1A range of manganese.

The reader is again reminded that these remarks are intended for reasonably broad interpretation, that their main object is to assist those who occasionally meet with difficulties in this direction, and finally that they are born of actual experience, and it has not been attempted to explain the occurrence in theory.

No mention has been made of sulphur which enters into combination with manganese, and its absence or presence in abnormal amounts will call for attention when considering a manganese content. But that is another story.

Distribution of Sulphur between the Gas Phase and Liquid Iron.

Summary of Laboratory Experiments.

THE state of equilibrium at high temperatures of the two reactions $FeS + H_2 \rightleftharpoons Fe + H_2S$ and $FeS + O_2 \rightleftharpoons Fe + SO_2$ has been determined by E. Maurer and F. Bischof, by laboratory experiments. A closed apparatus was used, in which, by means of a suction-pressure pump, a definite quantity of pure nitrogen, containing varying percentages of pure hydrogen sulphide and/or hydrogen, and sulphur dioxide and/or oxygen, respectively, was circulated in a continuous stream over the molten iron bath, the temperature of which was kept constant. The initial sulphur content of the iron was varied from 0 to 30%. Melting was performed in the Tammann furnace and high-frequency furnace. Gas samples for analysis were taken at the beginning, in the middle, and at the end of each experiment, and from the variation of the sulphur content of these three samples the trend of the reaction could be determined. By plotting the final sulphur content of the iron bath against the ratio H_2S/H_2 and SO_2/O_2, respectively found at the end of each experiment, and making allowance for the trend of the reaction, the equilibrium curves could be constructed. The experiments were carried out at 1,375 and 1,475° C. for the H_2S-reaction, and at 1,480 and 1,580° C. for the SO_2-reaction. The results of the present experiments were then compared with American experiments carried out on a large scale with open-hearth furnaces of 50 and 75 tons capacity, respectively. In those experiments samples were taken at various stages of the heat from different points of the metal bath, and at the same time from the gas shortly before entering and shortly after leaving the furnace. When the sulphur content of the incoming gas was converted into H_2S and the ratio H_2S/H_2 correlated with the corresponding sulphur content of the iron bath no definite relationship could be established. Besides this, the values were considerably lower than those found in the present experiments. When, on the other hand, the sulphur content of the waste gas was converted into SO_2, and the ratio SO_2/O_2 correlated with sulphur content of the iron bath, a curve was found which was in a fairly good agreement with the curves of the present experiments. From this fact the authors conclude that under practical conditions the variation of the sulphur content of the iron bath in open-hearth furnaces is primarily dependent upon the reaction $FeS + O_2 \rightarrow Fe + SO_2$. (*Archiv fur das Eisenhuttenwesen*, June, 1934.)

New Electric Steel-Smelting Furnace in Transcaucasia.

The first electric furnace for smelting steel in Transcaucasia has been put into operation in the Tsentrolit plant in Tiflis. At present the second furnace is being lined with refractory material.

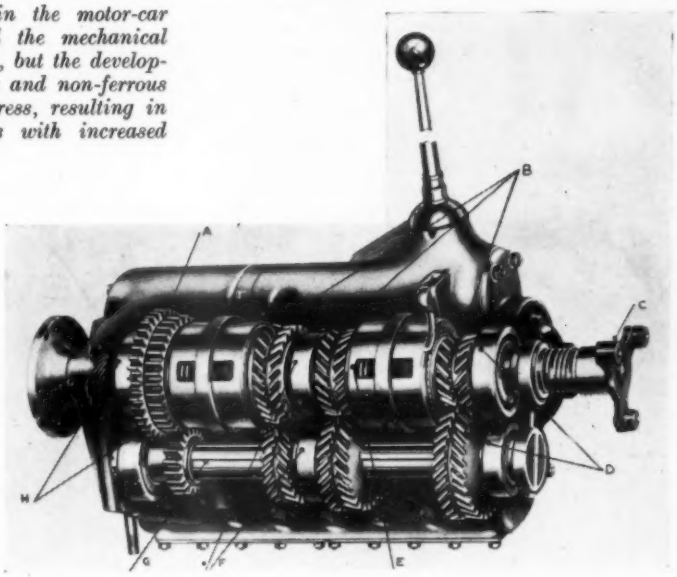
The first metal has already been obtained from a cupola recently mounted for smelting cast iron. In addition, the first two bays of the steel foundry of the plant have been completed and the third is under construction.

Progress in the Automobile Industry

Some Metallurgical Considerations of the Motor Show.

The demands for maximum efficiency in the motor-car industry have, in many cases, exceeded the mechanical properties of the materials formerly in use, but the development of various alloys in both the ferrous and non-ferrous fields have opened a new avenue of progress, resulting in economies in weight and greater speeds with increased reliability.

IT speaks volumes for the virility of the motor industry, that the Motor Show continues to be regarded as an event of national importance. Certainly the enthusiasm displayed by the industry and the public at the Twenty-Eighth International Motor Exhibition, now in progress at Olympia, indicates that it retains its fascination year by year. While it is generally recognised that the motor industry has made remarkable progress, manufacturers continue to stage new models with mechanical improvements and coachwork that make for still greater comfort, the whole tendency being towards increased all-round efficiency, together with a more pleasing appearance. Behind this continued desire for improved efficiency is the steady work carried out from year to year, not the least of which is that which concerns the materials used in the construction of the modern motor-car, and in this article it is proposed to make reference to some metallurgical aspects of the exhibits at this show.



A—First and reverse gears: nickel-chrome case-hardening steel. B—Constant-mesh double helical gears: air-hardened nick-chrome steel. C—Joint flange: mild steel. D—Roller journal bearings. E—Bronze cones inside all forward-gear engagement sleeves, with special angle and oil-film cutting grooves. F—Roller journal bearings. G—Mainshaft and lay-shaft in manganese case-hardening steel. H—Ball journal bearings: gear case aluminium alloy.

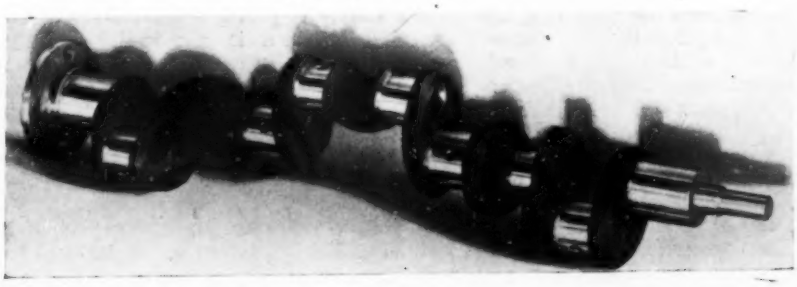
The patent all-silent all-synchromesh gearbox of the Alvis Car and Engineering Co., Ltd., showing the variety of materials employed.

It is doubtful whether greater application of the results of metallurgical research is made in any other industry than in the motor industry. This is readily understood when the extent of the motor-car trade is appreciated. The amount of material consumed in production is very great, and with a continual desire for greater reliability, it is natural that increasing attention should be given to the quality of materials used. But in addition to increased reliability every effort is being made to reduce the weight of cars, in order to effect economy in petrol consumption. It is in both these directions—reliability and lightness of structure—that the metallurgist is assisting the development of the industry. His efforts are not limited to the development or selection of a suitable material, but include the manipulation of the material and its subsequent treatment to give the desired results.

The trend in modern manufacture is towards improved quality in the various grades of ferrous and non-ferrous materials, particularly is this true of those metals and alloys upon which much forging work is necessary, and which are required to pass very stringent tests. Such materials are invariably expected to satisfy these tests after forging and heat-treatment, and as the operations involve much costly work, it is important that the quality of the materials is of high order; it is for this reason, for instance, that continual efforts are made to produce high-grade steels capable of superior mechanical properties and giving greater reliability and increased service. But it is not in steels alone that the motor-car industry depends, since a very wide range of metals and alloys enters into the construction of a motor-car, and keen rivalry exists in the desire to extend the use of ferrous and non-ferrous metals and alloys.

Some idea of the wide range of materials employed is indicated by the gearbox, a typical example being illustrated comprising a synchromesh system. As motorists know, the whole art of gear-changing, with an ordinary gearbox, is to match the speeds of the gears which it is desired to engage. This generally involves speeding up or slowing down one set of gears, and it is accomplished by accelerating the engine with the gear in neutral, or by letting the engine-speed fall; a system has been devised, however, by which this is effected automatically. Actually, small cone-clutches, integral with the sliding dog-clutches, by which the constant-mesh gears are engaged, are used to bring the dog-clutches to the same speed, that is, they synchronise them. The type illustrated is synchronised in all four speeds. Whether gear-changing is effected automatically or not, however, the stresses imposed in the transmission and the complexity of the unit demand that the materials be of high quality and, after suitable treatment, possessing the mechanical properties each component requires. Differences of opinion exist as to what constitutes the best material for a particular component, and the question of cost is usually an important

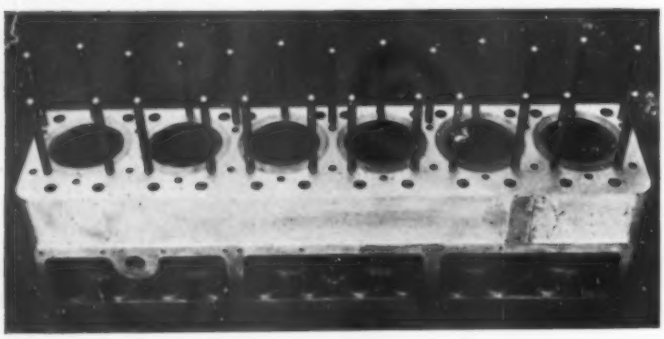
The crankshaft of the Vauxhall Light-Six engine, the part which is probably the hardest worked of any in a car; it needs to have great strength and rigidity.



factor, but all manufacturers realise that the quality of the material used must be high.

The variety of metals and alloys employed in the engine unit is also considerable, embracing both ferrous and non-ferrous materials. For the cylinder block the use of cast iron predominates, and efforts are being continually made to produce an iron which will resist abrasion and thus reduce cylinder wear to a minimum. Considerable success has been achieved in this direction, in some cases by the development of alloy cast irons containing nickel and chromium. One of the factors that influence the more general use of cast iron for the cylinder block, is the low relative cost, but aluminium cylinder blocks are being increasingly employed. In reciprocating parts increased smoothness and balance has been obtained by making use of light alloys. The aluminium alloy piston, for instance, has practically excluded the use of cast iron for that component.

Considerable variety exists in the grade of steel used in the motor-car industry, practically all grades from the dead soft carbon steel to the super grade alloy steels find a place. The industry has, for instance, been responsible largely for the demand for sheet and strip metal which could be readily shaped, free from tears, pulls and stretcher strains. The production of mild steel for such purposes is now a very high-grade production job, far removed from the condition obtaining in the mass production of what is generally termed mild steel. Certain alloy steels have been used with success for pressing work where greater strength is demanded than is available in dead-soft steel.



Cylinder block by High Duty Alloys Ltd., heat-treated Hiduminium R.R.50, fitted with steel liners.

Case-hardening steels are used to a considerable extent. With these steels it is well known that the properties required include easy machinability in the normal condition, the capacity of forming a high carbon case after treatment while retaining a tough core. The tough core required limits the carbon content of the steel, thus, when a steel is required to have a high-tensile strength than is possible in a low carbon steel and yet possess toughness of a high order, it is necessary to make alloy additions. Besides their superiority in this respect, the alloy case-hardening steels tend to reduce distortion during heat-treatment, because the desired properties may be obtained by oil quenching, instead of water quenching, further, the slower rate at which they absorb carbon renders them less liable to contain free cementite, and there is thus less likelihood of the case flaking. Nickel primarily influences the strength and ductility of steel, while this improvement in ductility and toughness can be combined with increase in strength, surface hardness, and depth hardening by the influence of chromium in the nickel-chromium alloy. The addition of molybdenum further increases the working strength and imparts advantages to the treated steel.

Many grades of forging steels are also employed in the industry, ranging from the medium tensile carbon steels to the well-known nickel-chromium-molybdenum steels. The extent to which the various grades of steel are used depends to some extent on the marketing price of the car, but high-quality of the particular grade is essential. The carbon steels have economical advantages, the medium tensile grade being readily welded, forged and machined, and under suitable treatment it responds with a combination of strength and ductility that has many applications. It will be appreciated that the greater the carbon content the greater will be the hardening strains in heat-treatment and the lower the ductility which can be obtained with a required tensile strength, thus, in determining the grade of carbon steel, it is customary to use a steel with carbon content as low as will give the desired properties.

When it is not desirable to increase the carbon content, yet superior mechanical properties are required than are obtainable from a straight carbon steel alloy, additions are made to improve the mechanical properties as desired. Of these alloy steels, probably the most economical is the carbon-manganese range. The chief alloying element is manganese, amounting to about 1·5%. The corresponding mechanical properties are, in most respects, intermediate between the plain carbon and more fully alloyed steels of similar carbon content. It is sometimes assumed that these steels are brittle in treatment, but with proper control of heating, forging, and finishing temperatures,

Aluminium-alloy piston and connecting-rod, with fittings, of the Vauxhall Light-Six. Smoothness and balance in operation are important factors determining the choice of materials.

and saturation on heating for hardening, followed by a rate of cooling determined by the carbon-manganese content in relation to the mass factors, these steels are not more sensitive than other steels used quite freely for similar purposes. With small additions of molybdenum or molybdenum and nickel, a steel possessing a remarkable combination of properties is obtained.

Originally added merely to give increased strength and toughness over that obtained in the ordinary rolled structural steel, the development and possibilities of heat-treatment have greatly enhanced the value of nickel, and despite the commercial applications of many other alloys, nickel steel continues to find increasing applications. The advantages of nickel are too well-known to need repetition here, but it is noteworthy that a steel with 0·25% carbon and about 3·0% nickel has a tensile strength equivalent to a 0·45% carbon steel, a proportionately greater elastic limit and the advantageous ductility of the lower carbon steel. It must be remembered that the

marked improvement in physical characteristics of nickel steels, as with other alloy steels, depends upon suitable heat-treatment.

The improvement in ductility and toughness conferred by nickel, and the increased strength, surface hardness, and depth hardening obtained from the addition of chromium are combined in the nickel-chromium steels, and a proper combination of the two alloys will accentuate the density of structure, reliability and responsiveness to heat-treatment, as well as confer distinctive properties not characteristic of either alloy when used alone. The beneficial effects resulting from the addition of molybdenum to nickel-chromium steels is now well-known; not only does it increase their toughness, but it diminishes the mass effect in hardening, and reduces the possibility of temper brittleness.

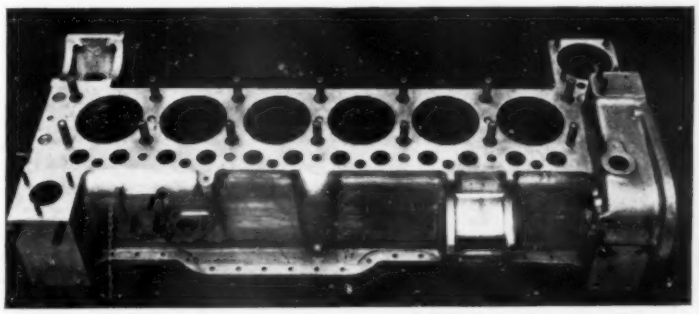
It has been possible only to make cursory reference to the steels used, but it is now fully recognised that the demands for maximum efficiency have, in many cases, exceeded the properties that can be obtained from straight carbon steels. Those steels containing various proportions of alloying elements which have been developed have opened up a new avenue of progress, resulting in economies in weight and greater speeds, with increased reliability, and providing better service.

On the ferrous side, mention may be made of the exhibits of the Clyde Alloy Steel Company Ltd., which include "Clyde Alloy N.R.M. 3," a direct oil-hardening gear steel which reduces the heat-treatment cost, and eliminates distortion after heat-treatment, with subsequent reduction of noise in the gear-box. Other steels included in this exhibit are the "Clyde Alloy 50" and "60" grades. The latest development to give an extremely hard surface consists in treating a suitable steel under specified conditions with ammonia gas. The process is also applied to alloy cast iron with remarkable success in the manufacture of cylinder liners. The nitrogen-hardened liner of the Sheepbridge Stokes Centrifugal Castings Company, for instance, is a distinct improvement in the solution of cylinder wear trouble. They are produced from a brand of alloy cast iron known as "Centrard," which is centrifugally cast and when nitrogen hardened in the bore, it gives a surface which combats, to a remarkable degree, the three main causes of cylinder wear, which are, according to the recognised authorities, corrosion, surface deformation and abrasion. The nitrogen-hardened surface —which penetrates up to ·020 in.—resists to a high degree the corrosive action of the products of combustion, and by reason of its high modulus of rigidity and absence of permanent set, resists surface structure deformation. In addition, the nitrogen-hardened surface has a Brinell hardness figure of over 900, and this, combined with its ability to take an exceptionally high polish, dispenses with much of the friction and abrasive wear on the cylinder surface. Liners made from this material are standardised by many manufacturers of compression-ignition engines.

In the manufacture of motor-cars the economic aspect, though important, is not usually brought so prominently before the notice of the owner as are the technical advantages he obtains in the matter of increased acceleration, greater power on hills, and so on. The present system of taxation has developed a type of car in which low weight is combined with a high speed, low-rated engine and consequently it is important that dead weight be reduced in every possible direction. For this reason, the applications of aluminium have made considerable progress, and many applications are accepted unanimously by all manufacturers. For example, the light alloy piston is practically universal, because of the saving in reciprocating masses, and the light-alloy connecting-rod is being used for the same reason. Aluminium crankcase, sump, gearbox, brake drums and rear axle casing are all well tried uses, and these applications are made with a view to direct weight saving.

In the cylinder block, it is the tendency to-day to cast the block and top-half of the crankcase in one unit in order to obtain maximum stiffness, and with such a casting it is sometimes found that the cylinder bore is relatively soft, and tends to wear badly. This has been overcome by the use of inserted wet liners of special alloy steel, and with such a construction it is an obvious step to produce the top-half of the crankcase and cylinder block as a light casting, removing much of the weight of the cast-iron block. That this application is well worth while is proved by the adoption of light-alloy blocks by several prominent manufacturers at the present time. The aluminium-alloy cylinder head is becoming increasingly popular, not only because of the weight reduction obtained, which may amount to about 1% of the total weight of the car, but also because a light alloy cylinder head gives considerably increased power output (an average figure of 10% is quite normal), together with reduced fuel consumption. This is due to the fact that the alloy head allows an increased compression ratio to be used, and this means an increased expansion ratio.

For bodywork, aluminium panelling is used in many types of cars, ranging from luxury vehicles, such as Rolls-Royce down to quite cheap mass-produced cars, and here the advantage of weight reduction is allied with high corrosion resistance and ease of panel formation. The tendency to simplicity of design, and the deletion of complex curvatures from motor-bodywork has opened the way to the production of panels by methods much more expeditious than by beating or wheeling. The power-driven percussion screw press is—with the use of suitable tools—capable of producing raised panels rapidly and at a fraction of the cost of hand-raised work. The surface of the metal remains smooth, reducing labour costs for finishing to a minimum. The ratio of pressure as between aluminium and steel is approximately 1 to 4: hence a saving on tools, machines and power.



An aluminium crankcase casting by High Duty Alloys, Ltd., in heat-treated Hiduminium R.R. 50.

The problem of low first cost versus higher cost and saving in running expenses is complex, and as old as trade itself, but it is interesting to note that some popular makes employ aluminium almost to the same extent as luxury cars, and it is these cars which show a minimum of depreciation. Usually a reduction in weight is advantageous in relieving bearing pressures, thereby reducing friction; simplifying balancing, thereby reducing vibration and noise; in lessening inertia, thereby reducing the energy absorbed in starting, stopping or changing speed. Ample proof is available of the ability of aluminium alloys to withstand high stress, fatigue and shock, and they have been adopted for a variety of moving parts. The alloy used depends largely on the nature of the parts. The highest available strength for the minimum of weight is obtained with forgings of Hiduminium, Duralumin and "Y"

alloys, but it is surprising how often a casting in one of the simplest aluminium alloys will stand up to severe conditions of operation which previously required the use of steel. This is due to the fact that the reduction in weight often of itself reduces the stresses thrown upon the moving part.

In addition to the types of aluminium alloys mentioned remarkable progress is being made in the application of magnesium alloys, which, although approximately 40% lighter than the aluminium alloys, have a very high relative strength. Some examples of these, together with castings in Birmabright, Zimal, and Birmasil Special are exhibited by the Birmingham Aluminium Casting (1903) Co., Ltd. Considerable interest is attached to examples of the Birmal Exceloid steering wheels, whose ingenious construction, consisting of Zimal pressure die-cast hollow-rim and a gravity die-cast aluminium centre and spokes, ensures great strength without brittleness or the weaknesses liable to occur, and due to contraction stresses, in a wheel cast in one piece. Examples of the Nelson Bohnalite Invar Strut Piston also attract attention; by means of an interesting design Invar alloy struts control the expansion of the aluminium alloy skirt of the piston in such a manner that correct clearance is maintained at all temperatures, resulting in the maintenance of oil consumption at an economical level, the reduction of cylinder bore wear to the absolute minimum, and thus giving quicker acceleration with less vibration and greater power in the engine. Excellent examples of light alloy castings are shown by Robert W. Coan, Ltd., these including castings in many special alloys.

On the non-ferrous side no exhibit illustrates the close control exercised in the manufacture of many forms of material used in the motor and accessory trades better than that of I.C.I. Metals, Ltd. The main use of strip or sheet in the motor trade is for radiators, for which purpose brass sheets are supplied of deep pressing quality capable of withstanding heavy draws, yet requiring a minimum amount of polishing prior to the plating process. Very close control in the manufacture of the sheet throughout all processes is necessary to obtain this combination of softness with smoothness after working. Brass sheet and strip are also very largely used for the production of radiator parts, such as tanks, etc., and examples illustrate the depth and intricacy of the pressing these sheets have to withstand. Brass and copper sheets and strip are also shown as used for carburetters, lighting sets and general accessories.

Amongst the many items of interest, both to manufacturers and users of motor-cars is a selection of "Oilite" self-lubricating bushes and bearings, exhibited by The Manganese Bronze and Brass Company. These bushes consist of a porous bronze material impregnated with lubricant. Their construction is such that a metered quantity of filtered oil is supplied at the required rate to the bearing surfaces. In addition, many high-duty alloys in the cast, extruded, rolled, stamped and forged condition are exhibited, together with ingots of manganese bronze and other non-ferrous alloys for castings. Of unusual interest among these exhibits is the interesting results of a series of machining tests which were carried out for us recently by one of the leading machine-tool manufacturers. The test specimens will show the effect of machining a wide range of non-ferrous alloys under different conditions, and will also demonstrate the types of finish obtainable under those conditions.

Of the wide range of non-ferrous products exhibited at the Show, mention may be made of the many grades of phosphor bronze casting alloys of The Phosphor Bronze Company, Ltd. There are five grades, these varying in hardness, and are graduated to meet different requirements. It is noteworthy that grade No. VII, when cast by the ordinary process has a tensile strength of about 12 tons per square inch, and when made into solid and cored stricks by the process adopted by this company, the tensile strength is increased to approximately 23 tons per square inch, and the elongation remains at 3 to 4%.

Surface Hardening by the "Shorter" Process

The "Shorter" process of hardening, as pointed out in previous articles on the subject, is effected by mechanically operating an acetylene flame suitable in size and degree to the area under treatment, over the surface to be hardened, and following this with a cooling jet to quench the heat imparted to the surface. This cooling jet follows immediately behind the heating flame, as it traverses the surface of the metal, so that quenching takes place immediately the steel is brought to the critical temperature. In connection with this process, an interesting investigation has been carried out under the direction of Dr. T. Swinden, of the Central Research Department of the United Steel Companies, Ltd.

Specimens of several grades of steel, both carbon and alloy steels, were hardened by the process, and after testing the hardness, transverse sections of the specimens were examined under a microscope. As a result of the investigation it was concluded that the "Shorter" process can be applied successfully to a wide range of steels. No advantage has been found in the use of alloy steels as regards the initial surface hardness or the depth of hardening. On the other hand, it is important to note that satisfactory hardness is developed in the case of alloy steels specially designed for their excellent mechanical properties in the body of the material, and it is suggested that the "Shorter" process might be developed with still greater satisfaction by the selection of suitable alloy steels in future.

Electrochemists Meeting in New York.

The Electrochemical Society, an international organisation devoted to pure and applied electrochemistry, and founded in 1902, held its meeting in New York City, recently. It is twelve years since the Society's last convention was held in New York, during which time six new metals have been discovered, three of these by American investigators. Professor B. S. Hopkins, of the University of Illinois, one of the foremost chemists of the country and discoverer of illinium, a metal with many valuable properties, discussed his researches in the rare metal field. Rhenium, a metal discovered a few years ago in Germany, can be electroplated, producing a coating very resistant to muriatic acid, an exceptional distinction. Messrs. Colin G. Fink, and P. Deren reported on this new electroplate. Of wide commercial importance is the metal barium, now being produced in fairly large quantities, and widely used in the vacuum tube industry. Of special interest is a nickel-barium alloy used in spark-plugs, which was reported upon by Mr. D. W. Randolph. Barium is also an aid in the operation of electric furnaces, according to M. A. Baerstein. Dr. Hans Osborg displayed samples of lithium alloys, including a very light alloy, composed of zinc, aluminium and lithium, which has properties resembling those of steel. It was reported that lithium-copper alloys have found commercial application. Mr. James Critchett presided at a session devoted to a Rare Metals Symposium, at which talks were given on titanium, vanadium, thorium, uranium, calcium, gallium, boron carbide, beryllium and others.

Entitled "Our Services," a booklet has been received from The Bureau of Information on Nickel, which describes in a lucid manner the services available to industry from this Bureau. The phenomenal growth in the uses of nickel is largely due to the institution of organised research to find new alloys and new uses for existing alloys. As the results of these researches became available they were brought to the notice of industry in the form of useful technical information—*i.e.*, data which could be applied to industry. With this booklet is a pamphlet giving a list of the publications published containing this data, a perusal of which indicates how comprehensively the field is covered. This booklet is undoubtedly of interest, copies of which are obtainable from the Bureau, The Mond Nickel Co., Ltd., Thames House, Millbank, London, S.W. 1.

Recent Developments in Tools and Equipment

A SIMPLE machine has been designed which, it is claimed, gives accurate information on the load-carrying capacity of lubricants. The machine also measures friction and calculates the wear-resisting properties of materials. It is manufactured by British Timken, Ltd., the makers of tapered roller bearings. This lubricant and wear-testing machine was developed during research work in the company's laboratories. Originally it was used for obtaining measurements of the film strength of lubricants. Later it was improved and adapted to perform the three functions mentioned.

The general appearance of the machine in operation on a test is shown in Fig. 1, while Fig. 2 shows the essential details of the load and testing lever system. The main features of the device are the lubricant container and return pump, the lever system, and the arrangements for direct or belt drive. The lubricant container holds about a gallon of lubricant, which can be raised to and maintained at any temperature up to 210° F. by means of an electric hot plate. When the machine is in use, the lubricant under test is constantly circulated by means of a pump in the base.

The Lever System.—The lever system consists of two levers, one above the other. The upper lever, carrying the test block, is known as the "load lever," and is pivoted on a knife-edge mounted in the lower or "friction lever." The latter, which is also pivoted on a knife-edge, has a stop at the unloaded end, and is provided with a Vernier scale and a sliding weight for obtaining accurate measurements.

A tapered mandrel carries the testing cup, and a notch in the adapter carried on the load lever is provided to take the test-piece. Friction is measured between cup and test-piece, and lubricant from the container flows regularly between the two contacting surfaces. The arrangement of the levers ensures that the test-piece is always in the same position relative to the revolving cup, and that the unit-loading over the length or surface of the two test-pieces is always constant.

The machine is arranged for either direct or belt drive by means of a 2 h.p. synchronous speed electric motor. An 8-in. pulley with a 3-in. face is mounted on an extension of the mandrel, and a keyway is provided so that the motor may be coupled direct to the mandrel if desired. The oil pump is mounted in the base of the machine, and is driven from the testing mandrel. In operation the lubricant from the container flows over the test-piece, the rate of flow being controlled by means of a valve in the pipe-line. It then enters a sump, whence it is pumped back to the container. The mandrel is mounted on two Timken tapered roller bearings to preserve positive alignment, and is tapered at the end opposite the drive to receive the test cup.

Test Procedure for Lubricants.—In using the machine for testing the film strength of lubricants, both test-pieces—that is, the cup and the block—are usually made of carburised steel, hardened to 60° C. Rockwell and ground. Four tests may be carried out with one test block, but each new test requires a new cup or a reground surface of the cup. Newly ground faces on both pieces are necessary to ensure accurate and uniform results.

Assuming both test-pieces are in position, and the lubricant is heated to the required temperature, the driving motor is brought up to the desired speed, and the lubricant is allowed to flow over the test-block. The loading lever is then loaded by means of weights until the desired unit pressure is obtained. The full load should be applied at once rather than gradually, because the first few seconds of operation determine the possibility of sustaining loads when near the scoring point.

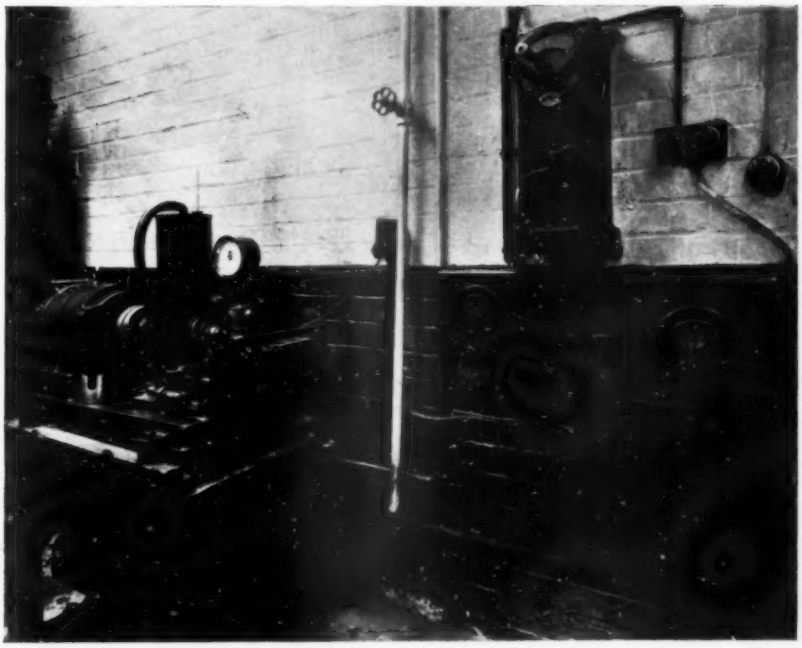


Fig. 1.—*General appearance of machine in operation.*

Breakdown tests are usually run for a period of 10 mins., and the surface of the block after test is the final check. If the surface is very scratchy or scored, then the load-carrying capacity of the lubricant has been exceeded. Rubbing speeds vary according to the type of test, and as an example it may be observed that lubricants for automobile rear axles are usually tested at 400 f.p.m. (800 r.p.m. of the spindle). Light oils, such as free-wheeling lubricants and motor oils, are tested at 200 f.p.m.

Greases may be tested by using a special chamber which surrounds the test-pieces. The chamber is filled with grease before the tests begin, and is kept filled by adding grease from a screw-down container which is interchangeable with the oil container supplied with the machine. Care must be taken to add grease at a constant rate in order that tests may be truly comparative.

Use of a Chart.—A chart provided with the machine shows the number of pounds avoirdupois placed on the loading lever in terms of 1,000 lb. of unit pressure on the test-pieces. The chart also shows the turning speed necessary to produce any given rubbing speed both by direct and belt drive, and also standard formulæ for use with the machine.

Measuring Friction.—Friction depends upon load, rubbing speed, type of materials in contact, temperature, and lubricant. Changing any one of these factors may change the friction. The uses to which the machine may be put are therefore most valuable. It is possible, for instance, to measure friction when the rubbing speeds, temperature, materials, and load are held constant and the lubricants varied. Likewise, the friction may be measured when the contacting materials are changed and the other factors remain constant. Friction, in short, may be measured under any desired condition relative to speed, pressure, temperature, lubricant, and bearing material.

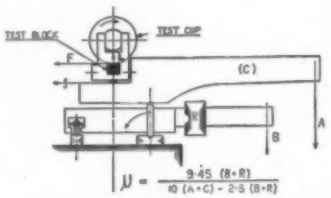


Fig. 2.—Essential details of the load and testing lever system.

A—Weight on the load lever. B—Weight on the friction lever. C—Load lever constant: the upward pressure at end of the load lever which balances the lever when the weight hanger is in place. F—Friction. P—Test pressure. R—Sliding-weight reading. U—Friction co-efficient. L—Length of scar on test-block. W—Width of scar on test block. S—Pressure per sq. in. on test block. The test pressure P is given by the formula: $P = 10(A + C) - 2\frac{1}{2}(B + R)$.

In friction tests it should be noted that the normal load on the test-pieces produced by the weight "A" on the end of the load lever, creates a force at right angles to the normal load depending upon rubbing speed, pressure, and lubricant used. This load in turn creates a force on the knife edge resting on top of the load lever, which is transferred to the knife edge on top of the friction lever. This tends to rotate the friction lever in a counter-clockwise direction, and this movement is resisted by a stop-pin fixed to the base of the machine. To measure friction, weights " B " are added by a slider and scalepan attached to the friction lever until it is just balanced—that is, until it just leaves the stop-pin. The coefficient of friction can then be obtained from the formula supplied.

Permanent records of tests carried out with various lubricants and materials may be kept by etching the used blocks with details of the amount of load imposed and the type of lubricant used. The amount and character of the scuffing on the blocks may be analysed and the results filed together with the blocks for future reference.

Wear Tests.—The machine, although originally designed to test lubricated surfaces, may also be employed to test packings, metal products, woods, plastics, textiles, and in fact any materials. Using either straight or curve-faced test blocks, simple wear tests may be made by weighing the specimens before and after test to determine the amount of material removed. If straight-faced test-blocks are used the width of worn surfaces may be measured and direct comparisons made.

Testing procedure, of course, varies according to the product under test, but any desired condition of rubbing speed and pressure may be used.

The machine, by its wide range of applications, is of use to many classes of manufacturers. The producer of oils and lubricants and the user of such products have a device for testing lubricants for any condition of service. The machinery and tool manufacturer has a means of giving proper lubricating instructions to users of his products. Producers of bearing alloys can obtain inexpensive and trustworthy data regarding the quality of metals, and manufacturers in general have here a testing apparatus which, as has been said, is capable of providing information previously obtainable only in the research laboratory.

Hard-metal Alloy Developed in U.S.S.R.

As a result of prolonged experimental work hard-metal alloys have been developed to replace expensive alloys imported by Soviet Russia. So successful has been the work that an alloy, known as " Sormite," is now being manufactured in quantities of 20 tons per day by the Central Institute of Metals, in Leningrad, while mass production of a second hard alloy, known as " Smena " No. 2, which will be used as a substitute for imported Stellite, is soon to begin. This latter alloy will effect considerable saving as it contains no cobalt, a costly metal in which the U.S.S.R. is deficient.

Sormite has already become regarded as indispensable to a number of industries, such as the tractor industry, machine building, oil, building, refractory materials, and anthracite coal industries. A thin layer of the alloy, from 1—3 mm. thick, welded on the surface of steel or iron gives it a high degree of hardness, durability, and resistance to abrasion and corrosion. Articles made from carbon and special steels last two to six times longer when covered with a surface of Sormite.

The manufacture of Sormite is carried out in a ½-ton electric furnace of the metallurgical laboratory of the Institute; casting is done in iron moulds, prepared by the Institute, and it is claimed that in hardness and appearance and in other properties the new alloy is equal to the best foreign examples of alloys used for similar purposes.

The Bullard-Dunn Electrochemical Metal Descaling Process.

THE development of the electrochemical descaling process for steel and other metals is described, and the underlying principles discussed, in a paper presented at the recent meeting of the Electrochemical Society, by Messrs. Colin G. Fink and T. H. Wilber. The process[1] consists in making the work or steel part the cathode in an acid electrolyte of low pH. The bath contains metal ions such as tin or lead, which are deposited as a thin film over the cleaned surface of the article. A cathodic current density much in excess of that normally used for electroplating such metals is employed. Hydrogen, liberated in copious amounts at the surface of the work, " blasts off " the scale and, concurrently, a metal film is electrodeposited on the work. The function of the metal film is to protect the descaled portions of the work until the descaling action is completed, and until the work is removed from the tank. It is believed that this metal deposit, wedging its way between the basis metal and the scale, is also effective in bringing about the scale removal.

The metal film furthermore prevents the work from becoming permanently embrittled, possibly by preventing the acid from destroying the intercrystalline cement. By comparative tests on spring-steel samples it was found that those samples which were acid-pickled became permanently embrittled, whereas those treated by this new process showed no trace of such damage. The real cause of permanent embrittlement by acid-pickling processes is still under discussion. It is our opinion that it is caused by the destruction of intercrystalline cement at the surface of steel as a result of etching. Since the Bullard-Dunn process does not etch the surface, no destruction of intercrystalline cement takes place, and, therefore, no permanent embrittlement results.

The use of silicon alloy anodes inhibits the oxidation of ferrous ions present in the electrolyte. A long life of the electrolyte is thereby assured, thus doing away with the objectionable, frequent renewals of electrolyte required by the older processes.

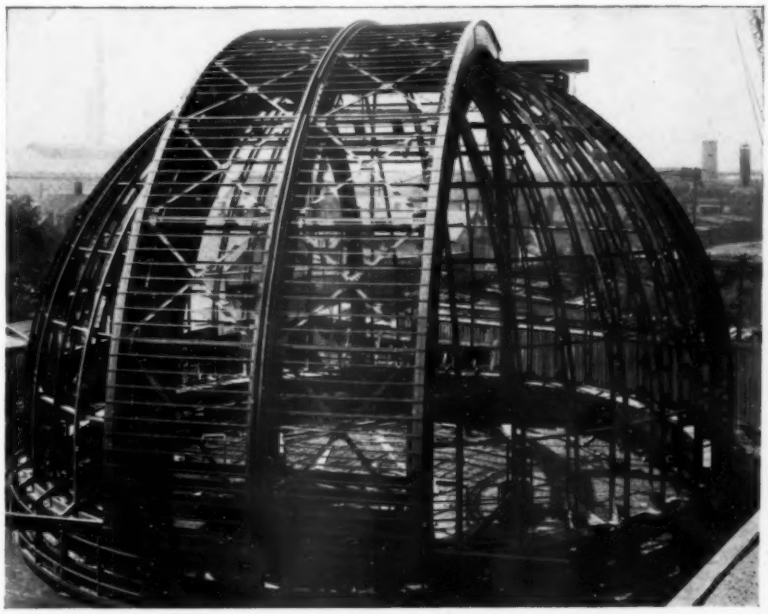
[1] U. S. Pat. to Thos. E. Dunn, No. 1,775,671, Sept. 16, 1930.

New Observatory on Mount Locke

A fabricated structure has been built, to house the world's second largest telescope, in which arc welding played an important part.

FRAMEWORK for a new observatory dome to house the world's second largest telescope was transported a distance of 1,500 miles to the summit of Mount Locke, in south-western Texas. The structure, fabricated and pre-assembled in Cleveland, with arc welding playing an important part, will be re-assembled near Fort Davis, 40 miles from the nearest railroad. There, on the mountain peak, the structure will be rooted to the earth, protected against earthquake shocks by arc-welded steel bracing, and astronomers of the University of Chicago and University of Texas, at an elevation of 7,000 ft., will begin new explorations of the solar system.

Mount Locke was chosen as the site of this new observatory because of unusually clear atmosphere, with better observing conditions than perhaps any other location in the United States. McDonald Observatory, as it is to be called, was designed by the Warner and Swasey Co., Cleveland, Ohio, for the University of Texas. In it will be placed an 80-in. reflecting telescope 26 ft. in length.



This dome for the new McDonald Observatory was transported 1,500 miles from Cleveland to its permanent home on Mount Locke, Texas.

The dome of the observatory has been erected in Cleveland by the Paterson-Leitch Co., under supervision of the Warner and Swasey Co., designers. It is 62 ft. in diameter, with a height above the foundation of 73 ft. Its construction required 125 tons of structural steel, and equal tonnage will be used in the sub-structure. After the building has been erected on Mount Locke, it will be covered with about 25 tons of galvanised iron sheets.

Floors of the structure are of the "battle-deck" type, entirely arc welded for rigidity. The first floor of the supporting structure will be used for libraries and offices. The second floor will contain sleeping compartments, laboratories, and photograph developing rooms.

Two main girders and a base ring constitute the main structural members of the dome, which is mounted on a plate and girder base, fastened to the top of the columns of the observatory building. The main girders are 4 ft. 6 in. deep, with $\frac{3}{8}$-in. web plates, $8 \times 6 \times \frac{1}{2}$-in. bottom chord angles, and $6 \times 6 \times \frac{3}{8}$-in. top chord angles. The semi-spherical contour of the dome is formed by the shaping of auxiliary ribs, which are fastened to the main girders and base ring. These auxiliary members are alternately 3- and 4-in. channels and split beams. Skirting hangars are of welded construction and fastened to the auxiliary ribs. Two 10-in. channels, reinforced by a 6-in. beam, form the bottom ring. These channels were joined with the flanges facing each other. The supports for the conductor bars, brackets, as well as the shield which prevents dirt getting into electrical conductors, are all of arc-welded construction.

An open space, 16 ft. wide, between the main girders, extends from the base of the dome to a point 9 ft. beyond the peak. This opening is covered by two movable shutters. Although the shutters weigh 16 tons they are so balanced that they are quickly and smoothly opened or closed by a 2-h.p. motor. Four movements of the dome mechanism are provided by push-button control within easy reach of the astronomer. The dome will revolve on 26 30-in. wheels, running on tracks mounted on the top girders of the sub-structure. The dome-turning mechanism is cable driven by a 5-h.p. motor.

Access to all parts of the dome and telescope is provided by an arc-welded electrically moved observing bridge running from the base to the top of the dome. This bridge is self-levelling. Arc-welded counter weights insure smooth movement of the bridge. A stairway, built as an integral part of the dome, gives access from the observer's floor to the bridge. Adjustable pulpits extend

Continued on page 190

Through this aperture astronomers will study the heavens, using the world's second largest telescope. Arc welding played an important part in the construction of the dome.

Reviews of Current Literature.

The Design and Construction of High-Pressure Chemical Plant.

ALTHOUGH the use of pressure vessels for effecting a chemical operation have been employed for some centuries in the industrial chemical field, nothing of importance in pressure technique was developed until the middle of the nineteenth century, when the discovery of synthetic dyes led to rapid improvements in really large high-pressure vessels, and to-day high-pressure autoclaves are an essential feature of many branches of dyestuff manufacture. In the various processes for the manufacture of synthetic ammonia also high pressures are commercially necessary; the pressures employed vary from 100–1,000 atms., and a reaction temperature of 400°–600° C. Even under these conditions the synthesis is only possible with the use of a catalyst. The success achieved in the development and operation of high-pressure synthetic ammonia plants has turned the attention of chemists and chemical engineers to other branches of the chemical industry, where high pressure may profitably be applied and where the technique acquired on the ammonia plants could be applied. The most successful of the developments which have resulted are perhaps the syntheses of methyl alcohol from carbon monoxide or carbon dioxide and hydrogen, and urea from carbon dioxide and ammonia. Other important developments of the application of pressure to facilitate chemical change include the hydrogenation of coal and crude oil.

In the development of the various processes much investigatory work has been carried out throughout the world with the object of designing suitable plant, and in this book the author has gathered together the most important aspects of the results and experience of these technical workers. Undoubtedly the most important developments have been made during the last twenty years, and it is over this period that Mr. Tongue has devoted his attention. His wide experience at the Chemical Research Laboratory of the National Physical Laboratory has contributed, in no small measure, in presenting information and data in this growing field which will be invaluable to all interested in the design and construction of high-pressure chemical plant. It is noteworthy that much of the information is published for the first time

The information and data given is comprehensive, yet the author has been able to compress it within the limits of 420 pages. He discusses compressors for high-pressure gas compression; the use of pressure in the preparation and purification of industrial gases; the design of pressure vessels for service at ordinary temperature; the measurement of pressure; valves, fittings, and pipework for high-pressure service at ordinary temperature; materials for service in high-pressure plant when exposed to high temperatures; the effect of low temperatures upon ferrous and non-ferrous materials; the design and construction of the chemical autoclave; high-pressure catalytic circulatory plants; and the manufacture of large pressure vessels for high-temperature service. In these discussions prominence has been given to those aspects which the author considers to be of greatest practical value.

It is appreciated that materials for use at high temperatures in the chemical industries must, in general, fulfil all the requirements for materials used under similar conditions in the ordinary engineering industries. They should not decrease markedly in strength when hot nor show a pronounced tendency to "creep" or to distort under load; they should not oxidise readily nor show marked increase in grain size. In addition to general requirements, however, materials in the chemical industries are subjected not only to heat and mechanical stress, but also to chemical action. In processes that involve working with acids, alkalies or corrosive gases it is necessary to consider the effect of temperature upon the rate of corrosion as well as its effect upon the purely physical characteristics of the metal. Furthermore, many of the reactions effected at high temperatures involve also the use of high pressures and the combination of the effect of heat pressure and chemical action may cause much more rapid failure than would be brought about by any one factor alone. In addition to elevated temperature and corrosion problems the chemical engineer is confronted with structural problems, as, for instance, the design difficulties involved in the high temperature, high-pressure catalytic process for the synthesis of ammonia and methanol. This book provides a fund of information on these problems, and although incomplete, inasmuch as the whole field is not covered and probably more information on non-ferrous metals and alloys could have given, it is doubtful whether so much valuable data on the subject is available in any other published work. Well produced and containing over 300 illustrations, the author has added a useful feature at the end of each chapter in summarising patents that are applicable, while subject and author's indexes are incorporated.

By HAROLD TONGUE. Published by Chapman and Hall, Ltd., 11, Henrietta Street, Covent Garden, London, W.C.2. Price 30s. net.

Journal of the Institute of Metals.

VOLUME LIII. (METALLURGICAL ABSTRACTS AND INDEX). VOLUME LIV. (PROCEEDINGS).

THE two latest volumes of the series issued by the Institute of Metals cover quite separate fields. The larger book includes many thousands of abstracts of papers of metallurgical and engineering interest that have been published recently throughout the world. In the work of compiling these abstracts the Editor has had the assistance of a staff of 50 scientific investigators, located in most European countries, a record of their names forming an impressive frontispiece to the volume. The value of these abstracts—which, prior to their publication in volume form, are sent out month by month to members—cannot be overrated, as a study of them enables workers in the wide field of non-ferrous metals to keep in closest touch with important technical developments in every part of the world.

Reference to the abstracts is facilitated by a surprisingly full index covering no fewer than 167 pages of closely printed entries. The book is valuable.

In the "Proceedings" volume is contained a record of original researches made by members of the Institute of Metals and presented at the recent London meeting of the Institute. The wide range covered by these important papers—13 in all—is indicated by some of the titles: "Castability of Ternary Alloys," by Professor A. Portevin and Monsieur P.Bastien; "Transverse Tests on Sand-cast Aluminium Alloy Bars," by C. E. Phillips and J. D. Grogan; "The Malleability of Nickel and of Monel Metal," by O. W. Ellis; "The Alloys of Silver and Beryllium," by H. A. Sloman; "The Diffusion of Zinc and Iron at Temperatures Below the Melting Point of Zinc," by G. Rigg; "Transformations in the Copper-palladium Alloys," by R. Taylor; "Alloys of Magnesium and Nickel," by J. L. Haughton and R. J. M. Payne; "Extruded Alloys of Lead-Tin and Bismuth-Tin," by C. E. Pearson; and "The Constitution of Copper-Iron-Silicon Alloys," by Professor D. Hanson and E. G. West. Preceding these papers is the Inaugural Address of the new President, Dr. H. Moore, C.B.E., and following them is the first verbatim record of the Annual May Lecture—the twenty-fourth of the series—as given by Professor E. K. Rideal, F.R.S., on "Gases and Metal Surfaces." The volume concludes with a full and appreciative obituary notice (with a reproduction of a photograph) of the late Dr. Walter Rosenhain, F.R.S., past-president of the Institute and one of the greatest metallurgists of all time.

Cloth. Edited by G. Shaw Scott, M.Sc., F.C.I.S. London: The Institute of Metals, 36, Victoria Street, Westminster, S.W. 1. (Price £4, inclusive of two "Proceedings" Volumes.)

Business Notes and News

British Steel Industry and the Cartel.

Important movements are taking place in the British iron and steel industry which will probably result in Great Britain becoming a member of the Continental Steel Cartel. There are, however, a number of vital considerations which have still to be agreed between the Cartel and the British Iron and Steel Federation, and until they are settled to the satisfaction of the Federation, Great Britain will continue outside the organisation.

The Continental Cartel has always desired British participation, but the terms on which entry was offered to steel manufacturers in this country have not been on sufficiently favourable terms. At the meeting of the Cartel in Prague last month, the British representatives were pressed to submit, at an early date, details of Great Britain's steel production, capacity, and requirements as regards quota and export markets. When the Committee of the Cartel met in Paris early this month, the details were not before them, and the matter has had to be postponed for consideration at a later meeting.

Membership of the Cartel is generally acknowledged by British steel manufacturers to be desirable on many grounds, and to deal with the negotiations in their final stages the Federation have appointed a Foreign Relations Committee.

The Admiralty announce that it has decided to allocate orders for a flotilla leader and eight destroyers, authorised by the 1934 Navy Estimates last March to the following firms :—Cammel Laird and Co., Ltd., Birkenhead, the flotilla leader ; W. Denny and Bros., Ltd., Dumbarton, two destroyers ; Scotts Shipbuilding and Engineering Company, Ltd., two destroyers ; Swan Hunter and Wigham Richardson Co., Ltd., Wallsend-on-Tyne, two destroyers ; Parson's Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne, two destroyers. The hulls of the two vessels allocated to the latter company will be built by Vickers-Armstrong, Ltd., at their Wallsend yard.

Firth-Brown Take Grid Supply.

A big development in the use of the grid system has taken place as a result of Thomas Firth and John Brown, Ltd. steelmakers and engineers of Sheffield, changing over from their private electricity supply to that of Sheffield Corporation. The development follows nearly twelve months of negotiation between the directors of the company and the Corporation. With two selected stations under the Central Electricity Board's grid scheme the Corporation have enormous supplies available. The company were faced with the problem of extending their own generating plant or taking a supply from other sources. They decided to close down their two large generating stations, and rely on the Corporation.

The works cover 140 acres. The two largest sections are practically three miles apart, and there are eight other smaller ones. Their present total electrical consumption is at least 80,000,000 units a year. Shortly they will be using 100,000,000 units. It is confidently expected that this action will enable Firth-Browns to develop the possibilities of electricity for additional power, particularly for large electric furnaces both for smelting and heat treatment. The power rate for electricity in Sheffield is claimed to be the lowest in the country, and with such a large bulk customer as these steel works, further reduction in the rate is likely.

Drawback on Stainless Steel.

The Treasury, on the recommendation of the Import Duties Advisory Committee, have issued the Import Duties (Drawback) (No. 17) Order, 1934, authorising, under Section 9 of the Finance Act, 1932, the continuance after October 8 of the drawback in respect of slabs of stainless steel of austenitic (18/8) quality used in the manufacture of stainless steel sheets of certain gauges.

Large Pumping Machinery.

The new sluice and pumping station at St. Germans, Norfolk, constructed at a cost of £224,000, was recently opened by Mr. Walter Elliot. This station will drain the heart of the Fens, and will deal with the flood-waters of the rivers Ouse and Nene. It is believed that this is the largest set of machinery of this character in the world, the pumps being more powerful than anything of the kind in Holland. The area they will drain includes 140,000 acres of some of the most fertile soil in England. The land represents a value of about £3,000,000, and the livelihood of many thousands of people.

Institution of Automobile Engineers.

Third Annual Report of the Research and Standardisation Committee.

The report dealing with the third year's work of the Research and Standardisation Committee, shows that the work carried out during the year has been very largely a continuation of the programme started in the year 1932-33. It is obvious that researches in hand dealing with cylinder wear, valve-seat wear, big-end bearing wear, and oil consumption, all involve prolonged tests, but very good progress is reported in these investigations, and the programme of research is being continually emplified. The investigation on cylinder wear still constitutes the main activity at the Chiswick Laboratory, and two reports on this subject have been issued to members. The last report deals with the causes of corrosion at low cylinder-wall temperatures, with tests on various fuels, and with experiments on upper cylinder lubrication. Preliminary tests on wear at high temperatures is also described, since it has always been realised that corrosion is not the only cause of wear. Tests are proceeding on various lubriating oils, on the effects of mixture temperature and mixture strength, on the design of piston rings, and on various cylinder-liner materials. Reference is also made in a report on valve-seat wear, which describes experiments that show the important influence on valve-seat wear of valve-closing velocity, operating temperature and valve material.

Comments are made on several other investigations in progress, on some of which reports have been issued, and results of considerable interest are being obtained from experiments in progress on piston temperatures at high engine speeds, on both water and air-cooled cylinders.

Proposed Amalgamation of Steel Works.

United Steel Companies Ltd. announce in the report for the year ending June 30, that the directors have decided to recommend the amalgamation of the Appleby Iron Company Ltd. and the Frodingham Iron and Steel Company Ltd., under the name of the Appleby-Frodingham Steel Company Ltd. These two works represent the large and important interests of United Steel Companies in North Lincolnshire, both being its subsidiaries, and the whole of the share capital of both being held by it. The two works are contiguous, and they are engaged in the same branch of industry. It is considered that by converting them into a single company their management and working would be greatly facilitated. The annual meeting of United Steel Companies is to be held on October 4, when it is expected that this proposal will be adopted. It is of interest to note that the improvement in the demand for semi-finished steel which the company was able to report a year ago spread to other products, with the result that the output of steel increased from 905,500 tons in 1932-33 to 1,351,000 tons in 1933-34. It is also stated that the directors have in view the consolidation at an early date of the loan capital of the company and its subsidiaries, with the prospect of a consequent saving in annual charges.

Central Experimental Station to Study Locomotive Design.

Mr. H. N. Gresley, Chief Mechanical Engineer of the L.N.E.R., in his recent presidential address to the Institute of Locomotive Engineers, announced that a scheme had been worked out for a central locomotive experimental station to be established under the auspices of the Department of Scientific and Industrial Research. The co-operation had been obtained of the railway companies, the locomotive manufacturing industry and locomotive consulting engineers. There was a committee composed of the chief mechanical engineers of the four leading railways, three locomotive manufacturers, two railway consulting engineers, two university professors and a representative of the Crown Agents for the Colonies. Sir Alfred Ewing would be the chairman. The station would be equipped with the most modern testing plant and include an up-to-date dynamometer car for use on railway tracks.

This proposal is an extension of previous work undertaken by the Department of Industrial and Scientific Research, which concerned the strength of bridges, and for which a bridge-testing laboratory was established at York. In recent years all railway companies have conducted experiments of their own regarding the type of locomotive best suited to haul heavy loads with a minimum of fuel consumption.

Acid Bessemer Steel Plant.

New Plant at Workington.

The Workington Iron and Steel Company, branch of the United Steel Companies, Ltd., has completed the construction of a new acid Bessemer steel plant which is the only plant of its kind in Great Britain.

It may be stated that acid Bessemer steel manufactured at Workington is made entirely from molten pig-iron produced at the Derwent mechanically-charged blast furnaces from pure Cumberland raw materials. At these works three blast-furnaces will presently be producing 7,500 tons of iron per week—one of these furnaces operating at the high rate of 3,000 tons per week.

The new plant, which is controlled by electricity throughout, consists of two 25-ton acid Bessemer converters, and will have a capacity of 7,000 tons of steel ingots per week.

Laid out on the straight-line principle, the Bessemer bay, which is served by a 100-ton overhead travelling crane, will effect considerable improvement in output and also facilitate the manufacture of high-quality acid Bessemer steel, which should assist in improving the position of the steel industry.

Catalogues and Other Publications.

Charles Clifford and Son Ltd., Fazeley Street Mills, Birmingham, have sent us a copy of the latest edition of their general catalogue, which is now available. It gives a description of the non-ferrous manufactures and specialities of this progressive firm, which include tubes, sheets and strips, wire, rods, chill-cast bars, and ingots. Valuable information for the buyer is tabulated in this booklet, a copy of which is available on application.

Copies of the first and second issues of the new Wild-Barfield Heat-Treatment Journal have been received, and those who appreciated the value of the Heat-Treatment Bulletins, formerly issued by this firm, will find a vast improvement in this new journal. The scope has been widened; the first issue, for instance, contains a comprehensive article by Mr. T. H. Burnham, on "Recent Progress in Metallurgy," while Mr. C. E. Foster discusses "Pyrometers in Industry," and Mr. W. E. Swale discusses "Electricity Supply." The journal is admirably produced and those desirous of being placed on the mailing list should apply to Wild-Barfield Electric Furnaces Ltd., Elecfurn Works, North Road, Holloway, London, N.7.

Evidence that this country is supreme in welding, is the fact that after several American firms had refused to undertake the work, saying it could not be done, the badly-damaged aluminium cylinder block fitted with steel liners belonging to an Hispano-Suiza engine, was sent for repair from New York to Barimar, Ltd., London. Within 14 days it was shipped back to America, repaired, and with a guarantee that the work done would be satisfactory in every respect

We have received an advance copy of the new edition of the Steel Foundry Book prepared by Messrs. Edgar Allen and Co., Ltd. This is the fourth edition of this useful work, and a radical change in arrangement has been made which has resulted in a more pleasing presentation of the information it contains. The contents have been divided into separate sections, thus: Section I. deals with steel castings for dredgers, mines, quarries, etc. Section II. deals with steel castings for wearing parts of ball mills, tube mills, and other crushing and grinding machines. Section III. deals with steel castings for heat and corrosion resistance. Section IV. discusses steel castings for permanent and dynamo magnets. Section V. has for its subject steel castings for all general purposes. Section VI. deals with the heat-treatment of steel castings, while section VII. consists of a paper on "Steel Foundry Welding," by V. G. Pearson. Section VIII. deals with the Edgar Allen steel foundry, and is followed by Section IX. which gives advice on how to order steel castings. Each of these sections is a separate pamphlet, but with a range of sections, an attractive binder is supplied. There are one hundred illustrations included, and the whole makes up a complete treatise on its subject. This is easily the best of the editions published, and those interested in steel castings will find the book both interesting and informative. Application should be made for a copy to Messrs. Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield, 9.

Some Recent Contracts.

Makers of file-making machinery in Sheffield have supplied a large number of file-making machines for the equipment of a factory near Moscow, and it is believed that orders for several hundred more machines for Russia will be placed in the near future with Sheffield manufacturers. Until comparatively recent times, Russia was Sheffield's largest overseas customer for files and rasps.

The Goole Shipbuilding and Repairing Company, Ltd., have obtained a contract from the Government War Department for the erection of a single-screw motor-ship.

Messrs. Topham Jones and Railton, Ltd., public works contractors of London, have secured the contract for the extension of the West Wharf at Singapore Harbour. The value of the contract is in the neighbourhood of £600,000, and the work is being done on behalf of the Singapore Harbour Board.

Messrs. Topham Jones and Railton built the graving dock at Singapore in 1909-1912, and reconstructed the wharves and built the Lagoon Dock in 1911-16. They also built the causeway carrying railway and road, which joins Singapore to the mainland.

Contracts for equipment for the Egyptian State Railways comprise special steels from Messrs. Thomas Firth and John Brown Limited, Sheffield, and Messrs. Arthur Balfour and Company Limited, Sheffield, and helical springs, Messrs. Willford and Co., Ltd., Sheffield.

The Crown Agents for the Colonies, have awarded Messrs. Nasmyth Wilson and Co., Ltd., of Patricroft, Manchester, an order for an additional six-wheeled coupled shunting locomotive for the Palestine Railways.

Important contracts awarded British engineers for overseas railway equipment include orders awarded to Messrs. John Baker and Bessemer, Ltd., of Rotherham, for locomotive and carriage tyres; and Messrs. Jonas Woodhead and Sons, Ltd., of Leeds, for elliptical springs for carriages.

Messrs. Vickers-Armstrong, Ltd., have received the contract for the construction at the Elswick Works, Newcastle, of two pair of gates for the 80-foot new entrance, four sets of hydraulic gate machinery and four sets of hydraulic sluices, in connection with improvements by the Aire and Calder Navigation at Goole Docks.

New Observatory on Mount Locke.

(*Continued from page* 187.)

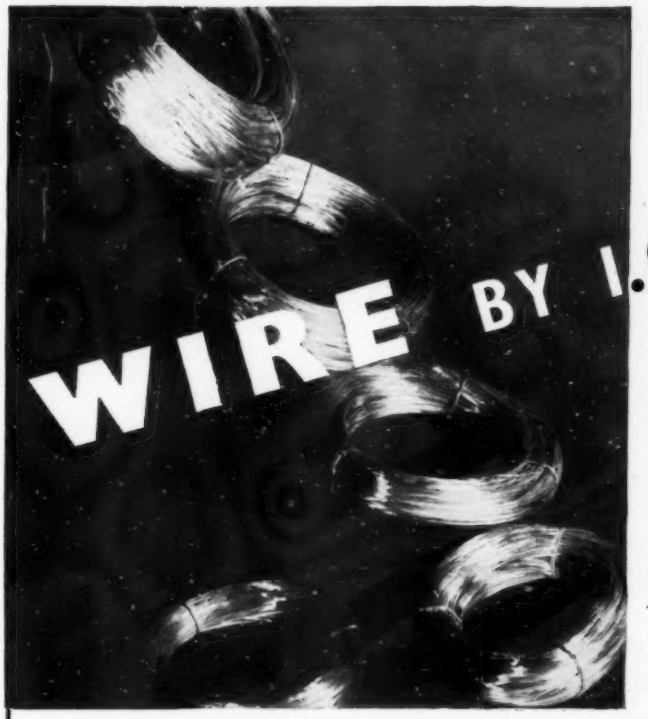
from the bridge and permit further adjustments of the telescope.

The two semi-circular elevating platforms, are welded on either side of the telescope pier, can be raised hydraulically 15 ft. above the observing floor. These platforms make it possible for the staff to make observations at lower points of the telescope tube.

Uniform temperature, necessary for greatest accuracy of observation, is assured by circulation of air between the inner and outer sheathing of the dome and sub-structure. Air enters at the foundation and passes up through louvres at the top of the dome.

To provide maximum protection against earth tremors, the earthquake bracing is to be entirely arc welded. Welding of the structural work, trucks, counterweights, observing platforms, stairways, doors and window frames, railings, floorings, earthquake bracings, and other welded parts is carried out by the shielded arc process, using Fleetweld electrodes and welding generators manufactured by the Lincoln Electric Co., Cleveland, Ohio.

Welding will also be employed in the construction of the 26-ft. telescope tube. Arc welding is said to surpass all other means of reducing deflection or sag in telescope tube construction. The construction of this new tube will be similar to that used in Perkin's Observatory, Ohio Wesleyan University, at present the third largest telescope in existence. Construction of the dome and sub-structure of McDonald Observatory began January 15, and will probably be complete before the end of the year.



High Conductivity copper wire for cables, etc.; hard drawn telegraph and telephone wire in copper and bronze; overhead trolley wire, round and grooved, in copper, cadmium copper and bronze; wire in copper, brass, phosphor bronze, and nickel-silver, in all qualities, for all purposes, round and shaped, plain and tinned; Kunial alloy wires; lead and zinc wires. These are some of the wire products of I.C.I. Metals Ltd. For further information, we commend our booklet "Wire," which, in addition to giving a comprehensive survey of the Company's activities in the manufacture of wire, contains an interesting description of modern wire production methods and useful technical data.

ICI

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High quality metals and skill in uniting them are of vital importance in maintaining the accuracy of this product. We have specialised in its production for many years, and it can be relied upon to give absolute satisfaction.

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SHUSTOKE

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ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£46	10	0
Chinese	41	0	0
Crude		—	

BRASS.

Solid Drawn Tubes	lb.	8½d.
Brazed Tubes	„	10½d.
Rods Drawn	„	8d.
Wire	„	7d.
*Extruded Brass Bars	„	3¾d.

COPPER.

Standard Cash	£26	0	0
Electrolytic	26	5	0
Best Selected	28	5	0
Tough	27	15	0
Sheets	56	0	0
Wire Bars	29	0	0
Ingot Bars	29	0	0
Solid Drawn Tubes	lb.	9¼d.	
Brazed Tubes	„	9¾d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	3
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL 2–4% Carbon, scale 11/- per unit	ton	31	0	0
NOMINAL 4–6% Carbon, scale 7/- per unit	„	23	0	0
NOMINAL 6–8% Carbon, scale 7/- per unit	„	22	0	0
NOMINAL 8–10% Carbon, scale 7/- per unit	„	22	0	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	34	0	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	10	0
§Guar. max. 0·7% Carbon, scale 15/- per unit	„	39	2	6
‡Manganese Metal 97-98% Mn.	lb.	0	1	3
‡Metallic Chromium	„	0	2	5
§Ferro-Vanadium 25–50%	„	0	12	8
§Spiegel, 18–20%	ton	7	10	0
Ferro Silicon— Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	10	0
45/50% basis 45%, scale 5/- per unit	„	11	17	6
70/80% basis 75%, scale 7/- per unit	„	18	10	0
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§Silico Manganese 65/75% Mn., basis 65% Mn.	„	14	0	0
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	15	6	0
§Ferro-Molybdenum, Molyte	lb.	0	5	6
§Calcium Molybdate	„	0	5	4

FUELS.

Foundry Coke—						
S. Wales	—			1	5	0
Scotland	—			1	8	0
Durham	1	0	0 to	1	5	0
Furnace Coke—						
Scotland	—			1	5	0
S. Wales	—			1	0	0
Durham	—			0	17	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£51	0	0
*Commercial Ingots	38	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 9
*Cored Bars	„	0	0 11

LEAD.

Soft Foreign	£10	5	0
English	12	10	0

MANUFACTURED IRON.

Scotland— Crown Bars, Best	£10	5	0	
N.E. Coast— Rivets	10	10	0	
Best Bars	10	2	6	
Common Bars	9	5	0	
Lancashire— Crown Bars	9	12	6	
Hoops £10 10 0 to	12	0	0	
Midlands— Crown Bars	9	12	6	
Marked Bars	12	0	0	
Unmarked Bars from	7	5	0	
Nut and Bolt Bars £7 10 0 to	8	0	0	
Gas Strip	10	12	6	
S. Yorks— Best Bars	10	15	0	
Hoops £10 10 0 to	12	0	0	

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	10d.
†Sheet to 10 W.G.	„	10½d.
†Wire	„	11½d.
†Rods	„	10½d.
†Tubes	„	1/4
†Castings	„	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland— Hematite M/Nos.	£3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast— Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands— N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants— Foundry No. 1	3	10	6
Forge No. 4	3	2	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	6	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 19·40 to £1 approximately.

Pig Iron Kr. 102
Billets Kr. 240-290 £13 10 0–£16 0 0
Wire Rods Kr. 280-320 £15 15 0–£17 12 6
Rolled Bars (dead soft) Kr. 200-220 £10 12 6–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton. f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£25	0	0
„ Braziery	22	0	0
„ Wire		—	
Brass	16	10	0
Gun Metal	22	0	0
Zinc	9	0	0
Aluminium Cuttings	66	0	0
Lead	9	10	0
Heavy Steel— S. Wales	2	14	0
Scotland	2	10	0
Cleveland	2	10	0
Cast Iron— Midlands	2	7	6
S. Wales	2	7	0
Cleveland	2	12	0
Steel Turnings— Cleveland	1	17	6
Midlands	1	13	0
Cast Iron Borings— Cleveland	1	7	6
Scotland	2	0	0

SPELTER.

G.O.B. Official		—	
Hard	£9	15	0
English	13	0	0
India	11	15	0
Re-melted	12	15	0

STEEL.

Ship, Bridge, and Tank Plates Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „		—	
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield— Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to 7/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£231	0	0
English	231	0	0
Australian		—	
Eastern	230	5	0

Tin Plates I.C. 20 × 14 box 18/-

ZINC.

English Sheets	£23	10	0
Rods	26	5	0
Battery Plates		—	
Boiler Plates		—	

* McKechnie Brothers, Ltd., quoted Oct. 12. † C. Clifford & Son, Ltd., quoted Oct. 12. ‡ Murex Limited, quoted Oct. 12.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§‖Prices quoted Oct. 12, ex warehouse.